EXTERNAL INSECT-ANATOMY

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A GUIDE TO THE STUDY OF INSECT ANATOMY AND AN INTRODUCTION TO SYSTEMATIC ENTOMOLOGY

BY

ALEX. D. MACGILLIVRAY

Be sure you are right,
Then look again.—COMSTOCK.

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TO

WILLIAM ALLEN SAVAGE

MY FIRST NATURE TEACHER

PREFACE

The author in the preparation of this book has had foremost in mind the needs of students. One of the most pressing demands for many years has been for a handbook giving directions for the detailed study of the external anatomy of a wide series of species of insects, a series of sufficient length to show something as to the evolution of the various types of structures. This has been attempted in the following pages, but is not uniformly complete for all portions.

That a thorough knowledge of the external anatomy of insects is fundamental to their taxonomy is self-evident. It was with this idea constantly in mind that the following studies were made and the results prepared for the use of students. The goal sought was not the preparation of a text-book upon the external anatomy of insects, but an introduction to the study of systematic entomology.

Only those who have carried through to completion a long series of comparative morphological studies have any conception of the amount of time required for the execution of such outlines as those given on the following pages. The preliminary studies were started when I came to the University of Illinois in the fall of 1911 and have been pursued almost continuously throughout the following school years and summers. The work could not have been brought to completion at this time if it had not been for the encouragement received from Professor Stephen Alfred Forbes, the former head of my department, and from the authorities of the University.

The directions were first prepared as laboratory outlines. Carbon copies were made which were loaned to the students. These were available to all students taking courses on the external anatomy of insects. To the students who have taken these courses I am indebted for countless suggestions and criticisms. Conclusions drawn from morphological studies are of real value only in comparison with the number of species studied. I have been fortunate during the course of my studies to interest several graduate students in particular parts of my problem. These students have been able to confine themselves in their investigations to a small region of the body for an entire order and to study this region intensively. They have had the benefit of my guidance and the use

of the outlines at their pleasure while I have had the benefit of their more intensive studies. Such an arrangement has been not only a mutual benefit but an inspiration to student and teacher. I wish to acknowledge my indebtedness to these students and give a list of their names. The researches of some have been published, some others are still to be published.

Daniel Milton Brumfiel—Henry Gordon MacGregor Crawford—Stanley Black Fracker—Theodore Henry Frison—J Howard Gage—Philip Garman—Clyde Carney Hamilton—Gladys Hoke—Joseph Lyonel King—Edna Mosher—Anna Grace Newell—Faustino Querales Otanes—Newton Lyman Partridge—Alvah Peterson—Lewis Bradley Ripley—Andrew Rutherford—Charles Stockman Spooner—Fenner Satterthwaite Stickney—Margaret Washington (Pfeiffer)—Paul Smith Welch—Hachiro Yuasa.

The names applied to the parts of animals fortunately are not subject to the rules of biological nomenclature. It, consequently, rests with the author to decide what names he shall adopt and what he shall discard. In several regions where the parts are of morphological value and not of taxanomic interest, I have not hesitated to change names in order to produce a more uniform nomenclature for associated parts. All names of long taxanomic usage have been adopted unchanged. While many synonymical terms are given, no attempt has been made to give them all. The hypothetical figures are solely to aid the student in locating the parts and for this reason they are indefinite in form. A bibliography has been intentionally omitted, since it is not of interest to beginning students, for whom this volume was prepared. Those desiring lists of papers dealing with the external anatomy can find excellent ones in the publications of Packard, Berlese, Folsom, Snodgrass, Crampton, and Comstock. The chapters dealing with the various parts of the body are not equally complete. The parts of the body most frequently used in taxanomic work have received the most extensive consideration.

The tendency of the times is the elimination of unnecessary circumlocutions. The application of prefixes in the thorax and abdomen to make the terminology more definite and concise is so startling, as put by a colleague in another field of biology, that it is likely to arouse opposition. Mesonotum and metanotum have long been used and other combinations are constantly being offered. Comstock states the problem as follows: "In designating the parts of the thorax the prefixes pro, meso, and meta are used for designating the three thoracic segments or corresponding parts of them. . . . This system leads to the use of a number of hybrid combinations of Latin and Greek terms, but it is so firmly established

that it would not be wise to attempt to change it on this account.'' Many will object to mesowing and mesoleg and accept mesospiracle and mesotergum, yet wing and leg are from the Icelandic, spiracle from the French, and tergum from the Latin. The practise in this volume differs from previous usage only in that the prefixes for the thoracic segments have been applied to all the parts. In addition to the prefixes differentiating the thoracic segments, a set of abbreviations is proposed by means of which not only the various segments of the abdomen but its different structures, can be distinguished. An attempt has been made throughout to unify the nomenclature and to produce for the names of the sclerites and sutures and associated structures a standardized set of names as has been done for the wings by the adoption by European and American workers of the Redtenbacher system of the naming of the wing-veins of insects. There is no likelihood that all of the names proposed will find ready acceptance, because such innovations, if adopted at all, come into use only through their gradual adoption in the class-room, by students, and by younger workers.

A thorough and comprehensive knowledge of external anatomy can be acquired only from the actual study and drawing of a considerable number of specimens. Such studies give excellent discipline and training in accurate observation, in the correct interpretation of the conditions observed, in the determination of the exact homology of structures that are often quite different in appearance, and in the molding of good habits in methods and proceedure in work, as well as to form the foundation and stepping stones for further studies.

An effort has been made to make the descriptions as inclusive as possible, so that in each structure studied there will be no portion that has been intentionally overlooked. While it will be desirable in each case to begin with the generalized species described, the descriptions have been prepared so that the different species described can be taken up in any order that the teacher may desire. A uniform nomenclature has been used throughout. This has become, because of the complexity of the parts, very complicated and extensive. The structures of the thorax for instance, which some text-books would lead us to believe are exceptionally simple, belong in reality to the most complicated series of structures of the body. The author has endeavored to remove this obstacle at least in part, by a general discussion of the structures and their relations at the beginning of each new subject considered which is followed by a concise definition with synonyms of each structure. While the nomenclature may at first seem cumbersome, the fact

that it is based upon a definite single worded system needs consideration. The proper pronunciation of scientific terms is always essential. The division into syllables and the marking of the accented syllables for each of the terms adopted in the text is shown in the index.

I am indebted in many ways to various individuals, to Professor C. L. Metcalf for many suggestions; to Dr. W. V. Balduf and Dr. T. H. Frison for reading parts of the manuscript; to Dr. R. D. Glasgow for suggestions and corrections; to Dr. Charles P. Alexander for an opportunity to study his unequaled collection of the wings of Tipuloidea and in many other ways; to Dr. J. Chester Bradley for the loan of mounted wings of Diptera and Hymenoptera; to Professor C. P. Gillette for the loan of a wing of Rhynchocephalus for figuring; to Dr. O. A. Johannsen for the loan of mounted wings of Mycetophilidae; to the staff of the Illinois State Laboratory of Natural History, S. A. Forbes, Director, the late Charles A. Hart, Mr. J. R. Malloch, Mr. W. P. Flint, and Dr. C. P. Alexander; to Professor J. G. Needham for the use of negatives from which prints were made and from which the drawings of the wings of the Odonata were prepared; and to Dr. Alvah Peterson and Ruth L. Dixon for aid in the preparation of the drawings from which the figures were made. All the drawings of the wings of adult insects were made from photographs by the use of blue-prints by the author.

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CHAPTER I

INTRODUCTION

The first comprehensive classification of insects was that proposed by the Swedish naturalist Carl von Linnaeus. This classification consisted of a division into orders, genera, species, and varieties. The genera were based upon the superficial characters of the head, thorax, and abdomen, and their appendages. The Linnean genera are in many cases the equivalent of the modern families. The orders were founded in the main on the number and structure of the wings. No attention was paid to the number, form, and arrangement of the veins. The ordinal names were formed by combining the Greek word for wing, pteron, with another Greek word indicating the number, structure, or character of the wing membrane, as follows:—Diptera, Coleoptera, Hymenoptera, and Hemiptera. For this reason his system is called the Alary System. The ordinal names proposed by Linnaeus, except Aptera, are still in general use.

This work of Linnaeus was followed a few years later by several volumes from the pen of the German systematic entomologist, John Christ Fabricius, who was a student of Linnaeus. Fabricius early appreciated the necessity for a more comprehensive knowledge of insect-anatomy. He made many such studies and based his classification upon the form of the palpi, maxillæ, labium, and antennae. New names were applied to all the orders, his names being based upon Greek words indicating the structure of the mouth. The Coleoptera of Linnaeus became the Eleutherata, the Diptera the Antliata, and the Hymenoptera the Piezata. The Fabrician system, because based upon the parts of the mouth, is known as the Maxillary System.

The appearance of the Fabrician system gave a great impetus to the study of the external anatomy of insects. The literature of this period contains many important monographic contributions to the subject. With a broader comprehension of anatomical detail there resulted a great multiplication in the number of genera and species. The few worded descriptions, usually not over two or

three lines, of Linnaeus and Fabricius gave away before the more detailed descriptions of the anatomists. Entomologists, then as to-day, were divided into factions, one group was insistent upon the value of the alary system, while another group was just as determined defenders of the maxillary system.

The first student who thoroughly appreciated the necessity for full and accurate analyses of genera and species, was the French naturalist, Jean Pierre Latreille. His work was done during the early years of the eighteenth century. He selected species typical of most of the various genera of all the orders as then known and published detailed descriptions, applying the results of the studies of the anatomists of his own and previous times. His work is the real starting point for the careful definition of genera. Appreciating the good features of both the Linnean and the Fabrician classifications, he endeavored to combine them into a single system. The classification of Latreille is known for this reason as the Eclectic System. Other systems of classification were proposed later, but none of them exerted so great an influence on anatomical studies as those mentioned above and need not be considered.

While the early entomologist used the form and gross structure of the body and its appendages for defining genera, the minutest details of the body of the insect are used by the modern systematist. The number and arrangement of the wing-veins are used wherever possible for the demarcation of genera and groups of genera. Where such characters are not available, the form of the mouth-parts, the number of tarsal segments, and the comparative length of each of these structures are used. The early describer depended upon color variations for the differentiation of his species, while the modern taxonomist uses for the most part the minutest microscopic details of the form and sculpture of various parts of the body, whether the surface is smooth or pitted, if pitted whether the pits are abundant or few, if abundant whether arranged promiscuously or in rows, if in rows whether so as to make a ridged or rugose surface. Not only the surface sculpture, but the vestiture of the body is taken into account. The vestiture consists of the large and microscopic setae, called hairs by many writers, scattered over the body and appendages. These setae are frequently promiscuously arranged, but may have a very definite arrangement. In certain orders the individual setae or groups of setae are of so much importance that they have been named. Their number and arrangement constitute excellent characters for differentiating species, genera, groups of genera, or even subfamilies. The impetus given to the study of the anatomy of insects by Fabricius is still

felt, and the multiplication of orders, families, genera, and species still goes on. It becomes more and more essential each day that any one, who hopes to do any constructive work of permanent value in systematic entomology, should have a thorough grounding in the elements of insect-anatomy.

Linnaeus in his "Systema Naturae," published in 1758, recognizes a class Insecta which is equivalent to the phylum Arthropoda of modern authors. He divided this class into seven orders, as follows: Coleoptera, Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera, and Aptera. The names of the first six of these orders are still in use although the limits of several of them have been changed considerably. The seventh order, Aptera, includes the wingless insects, the Crustacea, the Arachnida, and the Myriapoda. This ordinal group was soon broken up and the name discarded. A new ordinal name, Orthoptera, was later proposed for the cricket-like insects. The wingless insects included in the order Aptera were disturbed among the six Linnean orders and the order Orthoptera. Although new ordinal names were proposed from time to time, they were not generally adopted. The student of insects for many years recognized only seven orders, the six Linnean orders and the order Orthoptera. The tendency at the present time, however, is to adopt a class Hexapoda with nearly three times as many ordinal subdivisions. The great increase in the number of groups of ordinal rank dates from the work of Friedrich Brauer, 1885, who recognized seventeen orders. This was followed by the classification of Packard, 1886, with sixteen orders; Comstock, 1895, with nineteen orders; and Handlirsch, 1908, with thirty-five orders.

There is the greatest diversity of opinion not only as to the number of ordinal groups that should be adopted but also as to the way in which they should be arranged. The following synoptic table gives the number and arrangement of the orders recognized. This table, which is not an analytical table for the identification of specimens, also gives in tabular form the more important phylogenetic characters of the orders.

1. SYNOPSIS OF THE HEXAPODA

1. APTERYGOTA.—Insects primitively wingless; metamorphosis direct, prometabola.

Abdomen with two many-segmented cerci; abdominal segments numerous; abdominal coxal glands numerous; eyes compound or simple, ocellalae.—The Bristle-tails..........................1. THYSANURA.

Abdomen without cerci, with furcula, abdominal segments few in num-

ber; abdominal coxal glands never more than one pair; eyes simple, ocellalae.—The Spring-tails ---------------------------2. COLLEMBOLA.

II. PTERYGOTA.—Insects typically winged; metamorphosis direct or indirect, exometabola and entometabola.

EXOPTERARIA.—Wings developed externally; metamorphosis direct and incomplete, exometabola.

Mouth-parts fitted for biting.

Pronotum a quadrangular or a subquadrangular area.

Head vertical; tarsi primitively five-segmented; thoracic sclerites primitive in form and arrangement.—the Cockroaches, Mantids, Phasmids, Grylloblatids, Gryllids, Locustids, Acridids----------- 3. ORTHOPTERA.

Head horizontal; tarsi usually with three or less segments.

Probasitarsus normal in form, not provided with spinning glands.

Metawings larger than mesowings.

Cerci long, many-segmented; mesowings membranous; immature stages aquatic.—The Stone-flies-----4. PLECOPTERA.

Cerci modified into movable forceps; mesowings veinless wing-covers; immature stages aerial.—The Earwigs------- 5. EUPLEXOPTERA.

Metawings subequal or slightly smaller than mesowings; wings always shed and usually caducous.—The Termites, Zorotypids --------------------------------------6. ISOPTERA.

Probasitarsus abnormal in form, dilated and provided with spinning glands.—The Embiids---------------------7. EMBIOPTERA.

Pronotum reduced to a small transerse area, much broader than long.

Laciniae modified into maxillary rods; immature stages never aquatic.

Eyes compound; front and clypeus greatly swollen.—The Bark-lice, Book-lice-----------------------------------8. CORRODENTIA.

Eyes simple, ocellanae; front and clypeus flat.—The Bird-lice or Biting-lice ------------------------------------9. MALLOPHAGA.

Laciniae never modified into maxillary rods; immature stages aquatic.

Mesepisterna contiguous on dorso-meson; wings subequal or metawings slightly larger; prolegs subequal or shorter than others.—The Dragon-flies -------------------------10. ODONATA.

Mesepisterna normal in form; mesowings distinctly larger than metawings; prolegs of male distinctly longer than others.—The May-flies ------------------------------------11. EPHEMERIDA.

Mouth-parts fitted for sucking.

Mouth-parts asymetrical; maxillary and labial palpi present.—The Thrips --------------------------------------12. PHYSOPODA.

Mouth-parts symmetrical; maxillary and labial palpi always wanting.

Feet never scansorial; sucking tube formed of bristle-like mandibles and maxillae.—The Bugs, Cicadas, Leaf-hoppers, Aphids, Coccids .... 13. HEMIPTERA.

Feet scansorial; sucking tube a closed retractile structure.—The Lice .... 14. ANOPLURA.

ENTOPTERARIA.—Wings developed internally; metamorphosis indirect and complete, entometabola.

Head provided with a gula; mouth-parts fitted for biting; head prognathrous or hypognathous.

Pronotum large and quadrangular; mandibles present in all stages; head prognathous.

Mesowings veinless wing-covers; larvae typically without a gula.—The Beetles .... 15. COLEOPTERA.

Mesowings always membranous; larvae typically with a gula.—The Dobson, Aphis-lions, Hemerobiids, Ant-lions, Mantispids .... 16. NEUROPTERA.

Pronotum small and inconspicuous; mandibles present in larvae, decussating in pupae, wanting in adults; head hypognathous.—The Caddice-flies .... 17. TRICHOPTERA.

Head never provided with a gula; mouth-parts fitted for biting or sucking.

Wings four in number.

Mouth-parts modified, of the semisucking type; mandibles of the biting type and always present; body and appendages never covered with scales.

Head and mouth-parts not prolonged into a trunk-like structure.

Mesowings veined and larger than metawings; mesothorax never ring-like, pronotum collar-like, mesothorax much larger than either prothorax or metathorax.—The Saw-flies, Ichneumon-flies, Ants, Wasps, and Bees .... 18. HYMENOPTERA.

Mesowings minute veinless elytra-like structures, much smaller than folded metawings; mesothorax ring-like, metathorax larger than prothorax and mesothorax together.—The Stylops .... 19. STREPSIPTERA.

Head and mouth-parts prolonged into a trunk-like structure; mesowings and metawings subequal in size; thoracic segments all subequal.—The Scorpion-flies .... 20. MECOPTERA.

Mouth-parts modified, of the sucking type; mandibles other than rudiments rarely present; sucking tube formed from galeae of maxillae; body and appendages covered with scales.—The Moths and Butterflies .... 21. LEPIDOPTERA.

Wings two in number or wanting.

Pronotum large and conspicuous; metathorax subequal or larger than the mesothorax; labrum-epipharynx apparently wanting; labium other than labial palpi small, inconspicuous.—The Fleas. 22. SIPHONAPTERA.

Pronotum minute; metathorax small, much smaller than mesothorax; labrum-epipharynx always present; labium large and prominent, labial palpi always wanting.—The Flies .... 23. DIPTERA.

2. TECHNICAL NOMENCLATURE

A common practise among systematists in describing animals is to use such terms of direction as before and behind, above and below, inner and outer, anterior and posterior. These terms are generally used in such a loose and indefinite manner that it is impossible to locate with certainty the point that was in the mind of the describer. This difficulty is increased by the fact that, while the body-axis of many animals is a horizontal one, yet in the animal with which we are most familiar, man, it is vertical. With the change in the direction of the axis of the body, the terms above and below would refer to entirely different regions. Difficulties are encountered with insects in identifying points on the wings from the fact that some describers refer to them as if they were held in a horizontal position at right angles to the axis of the body, while others as if they were held horizontal and parallel with the axis of the body. Before and behind in such descriptions would refer to very different regions of the wing, depending upon the position assumed when the description was prepared. It is often difficult and sometimes impossible to tell from the context what that position was.

The nomenclature adopted on the following pages was devised by Professors B. G. Wilder and S. H. Gage for use in descriptions of anatomical details and later applied to the study of insects by Professor J. H. Comstock. It has been criticised as inelegant and unwieldy. The first prerequisite of all scientific work is accuracy. The primary feature of taxonomy is the identification of structures from descriptions. To insure accuracy in identification, the nomenclature denoting location and direction must be accurate and concise. The possibility of the precise location of points is so much greater with this system than with any other with which the author is acquainted that no additional reason for its adoption here is needed.

This system is a modification of the principles underlying the mariner's compass so that points in any plane can be located just as accurately as the points in a single plane. The compass is of value only in indicating points upon a horizontal surface. In studying solids, as the body of an animal, points upon a vertical surface must also be taken into account. The needle of the compass for locating points upon a horizontal surface revolves about the center of a circle, the needle of the hypothetical instrument for locating points upon the surface of a solid would revolve about the center of a sphere. Consequently there would be six (Fig. 1) instead of four cardinal directions as in the case of the compass.

PARTS OF SPEECH.—The terms used in denoting position and direction of parts are either adjectives or adverbs. They are derived from nouns, the names of the surfaces or aspects.

Nouns.—The following names are applied to the surfaces:—dorsum, venter, dextron, sinistron, latus, cephalon, cauda, meson, proximus, distus, ecton, and enton.

Adjectives.—The adjectives, except cephalic, end in *al* and are dorsal, ventral, dextral, sinistral, lateral, cephalic, caudal, mesal, proximal, distal, ectal, and ental.

Adverbs.—The adjectives are transformed into adverbs by substituting for their ending *al*, the termination *ad*, which is equivalent to the English termination, *ward*. Some dictionaries have introduced an undesirable form by adding *ally* instead of *ad*. The adverbs used are:—dorsad, ventrad, dextrad, sinistrad, laterad, cephalad, dorsad, mesad, proximad, distad, ectad, and entad.

ASPECTS OF BODY.—A cube or the body of an insect has six surfaces. Each of these surfaces under the nomenclature here used is known as an aspect.

Dorsum.—The back of an insect is known as the dorsum and includes all parts of the back. The adjective derived from this noun is dorsal and the adverb is dorsad.

Venter.—The underside of the body, the surface or aspect opposite to the dorsum, is known as the venter and includes all parts of the under surface. The adjective derived from this noun is ventral and the adverb is ventrad.

Dextron.—The right side of the body is known as the dextron and includes all parts of the right side. The adjective derived from this noun is dextral and the adverb is dextrad.

Sinistron.—The left side of the body is known as the sinistron and includes all parts of the left side. The adjective derived from this noun is sinistral and the adverb is sinistrad.

Latus.—The surfaces connecting the dorsum and venter on each side, the dextron and the sinistron, are identical in form. Each of these surfaces is known as a latus. The adjective derived from this is lateral and the adverb is laterad. Dextron and sinistron and the adjectives and adverbs derived from them are rarely used. They are replaced by latus, lateral, and laterad.

Cephalon.—The vertical surface at the head end of the body is known as the cephalon. The adjective derived from it is cephalic and the adverb is cephalad.

Cauda.—The vertical surface at the opposite or tail end of the body is known as the cauda. The adjective derived from this noun is caudal and the adverb is caudad.

Meson.—The name of meson is applied to the imaginary plane by which bilaterally symmetrical animals are divided into two similar right and left halves. The dorsal portion of this plane is known as the dorso-meson and the ventral as the ventro-meson.

CARDINAL DIRECTIONS.—The terms used in designating the six aspects of the body are applied to the six cardinal directions. None of the following terms are limited to any particular part of the body. They are relative. The cephalic part of the head has a caudal portion, the dorsal part of the back has a ventral portion, and the distal part of a leg has a proximal portion.

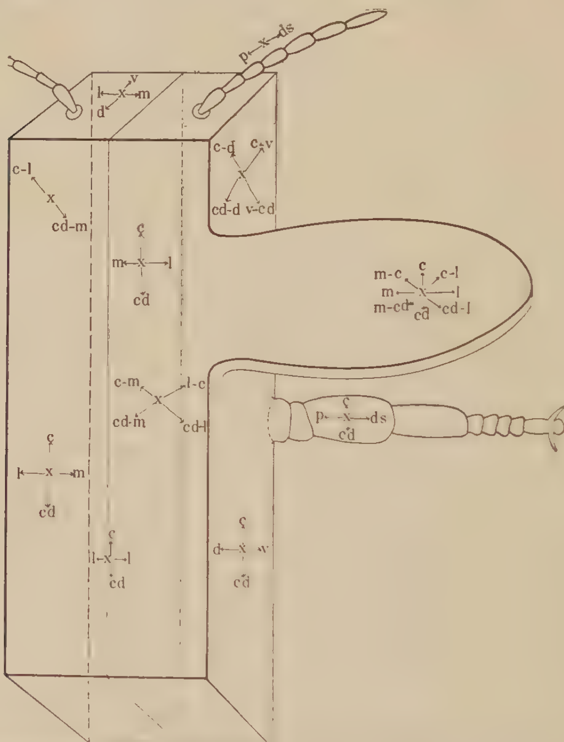

Fig. 1.—Hypothetical insect, showing cardinal directions: *c*, cephalic; *cd*, caudal; *d*, dorsal; *ds*, distal; *l*, lateral; *m*, mesal; *p*, proximal; and *v*, ventral.

Cephalic.—This is in a direction (Fig. 1, *c*) indicated by a line drawn from any part of the body, parallel to the meson, to or beyond the head. All lines drawn in a cephalic direction are parallel to each other and to the meson.

Caudal.—This is in a direction (Fig. 1, *cd*) indicated by a line drawn from any part of the body, parallel to the meson, to or

beyond the tail. It is the opposite of the cephalic direction. All lines drawn in a caudal direction are parallel to each other and to the meson.

Lateral.—This is a double direction (Fig. 1, *l*), to the right or to the left, away from the meson. It is equivalent to the dextral direction or the sinistral direction and is in a direction indicated by a line drawn from any part of the body, perpendicular to the meson, to or beyond the side of the body. All lines drawn in a lateral direction are parallel to each other and perpendicular to the meson and all cephalic and caudal lines.

Mesal.—This is in a direction (Fig. 1, *m*) indicated by a line drawn from any part of the body, perpendicular to the meson, to or toward the meson. It is the opposite of the lateral direction. Lines drawn in a mesal direction are parallel to each other and all lateral lines, but perpendicular to the meson and all cephalic and caudal lines. All lines that originate on the meson, if perpendicular to the meson, extend laterad. Lines extending toward the meson are mesal lines and those extending away from it lateral lines. If a point off the meson is indicated by a letter x, then the line that extends parallel to mesal and lateral lines and from the mesal side of the x toward the meson, extends mesad and the line extending from the opposite or lateral side of the x away from the meson, extends laterad.

Dorsal.—This is in a direction (Fig. 1, *d*) indicated by a line drawn from any part of the body to or beyond the back and perpendicular to all cephalic, caudal, mesal, and lateral lines. All lines drawn in a dorsal direction are parallel to each other and perpendicular to the lines indicating each of the preceding directions.

Ventral.—This is in a direction (Fig. 1, *v*) indicated by a line drawn from any part of the body to or beyond the underside of the body and perpendicular to all cephalic, caudal, mesal, and lateral lines. All lines drawn in a ventral direction are parallel to each other and to all dorsal lines.

Oblique Directions.—An oblique direction is indicated by a line drawn between two points through two or three aspects and named from the aspects through which it passes. Such directions, therefore, are indicated by a compound or hyphenated term, the termination of the word preceding the hyphen being replaced by the vowel o. The order of the parts in the hyphenated word is immaterial. Thus, dorso-cephalic, cephalo-dorsal, meso-cephalad, meso-caudo-ventral, or cephalo-dorso-laterad. Compound terms may be used in a similar manner to designate aspects between the

primary aspects. Thus, dorso-lateral aspect, dorso-caudal aspect, or cephalo-ventral aspect.

Natural and Normal Positions.—A natural position is the one ordinarily assumed by the animal during life. A normal position is the one in which an animal is placed by the describer and is usually entirely different from the natural position. The normal position offers greater facility in indicating directions than the natural position, but such a position of an animal is much more difficult to visualize and for beginners to grasp. In the descriptions given on later pages the animal, except the appendages and a few other parts, has been described from the natural position.

Aspects of Appendages.—The wings have been considered as if extended in a horizontal position at right angles to the meson. The legs are regarded as if extended horizontally at right angles to the meson, the knee joint being held dorsad and the bottom of the foot, the part applied to the ground in walking, being held ventrad. The appendages have four aspects, dorsal, ventral, cephalic, and caudal, if the two ends are disregarded. The mouth-parts have been described from the natural position.

Proximal and Distal.—These terms are applied only to the appendages of the body, and in combination with those described in the preceding paragraphs cover all the aspects of an appendage. Proximal (Fig. 1, *p*) indicates nearness to the end of the portion that is attached to the body. Distal (Fig. 1, *dt*) indicates nearness to the free or unattached end of an appendage.

Ectal and Ental.—These terms should be used only in describing and comparing the inner and outer parts of the body. Ectal indicates nearness to the external surface of the body. Ental indicates remoteness from the external surface of the body and is properly applied only when used in reference to structures within the outer covering of the body or cuticle.

Numbering Series.—The appendages are usually composed of a series of segments. These segments are numbered, first, second, third, etc. The proximal segment is always the first segment. When it is necessary to refer to any of the segments between the proximal and the distal, they are designated as the intermediate segments. The segments of the abdomen are numbered beginning at the cephalic end.

3. GENERAL CONSIDERATIONS

Before proceeding to a technical discussion of the various structures of the body of an insect, some attention needs to be given

to its more general features, together with methods of study, the preparation of specimens, and the making of drawings.

Body Regions.—Insects belong to that large phylum of the animal kingdom, the Arthropoda, which has for one of its most salient characteristics the division of the body into a linear series of ring-like segments, some or all of which bear a pair of segmented appendages. The segments are also known as somites or metameres. The external surface of the segments and of their appendages is hardened by the deposition within it of a hard substance known as chitin. This hardened surface is the external skeleton which serves to protect the vital organs enclosed within. The segmentation of the caudal part of the body is usually distinct, while that of the cephalic part is more or less obscure. The segments of the body of an insect are grouped into three regions: head, thorax, and abdomen.

Head.—The cephalic region of the body is the head. It can be identified from the fact that it bears a pair of long feeler-like appendages. The head of an adult insect appears to be unsegmented, but an examination of embryonic individuals shows that the head is composed of at least six segments, a segment for each pair of appendages that it bears.

Thorax.—The second region of the body is the thorax. It can be identified from the fact that it bears three pairs of legs and usually two pairs of wings. The presence of three pairs of legs is proof that it consists of three segments. In many insects the thorax appears to consist of only two distinct regions. This is due to the fact that the cephalic portion, which is the first thoracic segment and bears the first pair of legs, is frequently loosely united to the second segment of the thorax. The caudal portion consists of the second and third segments which are generally closely grown together. They bear the second and third pairs of legs and the first and second pairs of wings.

Abdomen.—The third region of the body is the abdomen. It is distinctly segmented and does not bear any appendages for locomotion. The appendages borne at the caudal end of the abdomen, sometimes concealed, are for copulation or ovoposition and are derived from the abdominal segmental appendages of the embryo.

Typical Body Segment.—A body segment is generally considered as consisting of four faces, a dorsal surface, two lateral surfaces, and a ventral surface. The nearest approach to such a segment is found in the wing bearing segments of the thorax. These segments are four-sided and each of the sides is considered as a

definite region. They are known as the tergum, sternum, and pleuron. These names are used in other parts of the body, the head and the abdomen, although the segments in these regions are not similar to those of the thorax in form.

Tergum.—The entire dorsal part of a segment is considered as a tergum and one of the subdivisions of the dorsal part of a segment as a tergite. Some writers designate the entire dorsal part of the body as the tergum and the dorsal part of a segment as a tergite. The dorsal part of a thoracic segment is also known as a notum.

Pleuron.—The entire lateral part of a segment is considered as a pleuron and one of the subdivisions of the lateral part of a segment as a pleurite. The entire lateral part of the body is designated by some writers as a pleuron and the lateral part of a segment as a pleurite. Each segment consists of two similar lateral surfaces, dextral and sinistral. They are known collectively as the pleura. The primitive segment, consequently the typical segment, consists of only a tergum and a sternum. The pleuron is a specialization that has arisen through the development of appendages for flight because of the necessity for space for the muscles to operate them.

Sternum.—The entire ventral part of a segment is considered as a sternum and one of the subdivisions of the ventral part of a segment as a sternite. The entire ventral part of the body is designated by some writers as the sternum and the ventral part of a segment as a sternite.

Body-wall.—The outer covering of the body of an insect is known as the body-wall. It is composed of three parts: cuticle, hypodermis, and basement membrane.

Cuticle.—The cuticle is the hard outer covering or skeleton, also known as the cuticula. It frequently consists of several consecutive indefinitely defined lamellae or layers. The outer or oldest layer is dense and homogenous and is the portion shed when the insect molts. This layer is inelastic and is known as the exocuticle, also as the epidermis or primary cuticle. The inner layers are usually lighter colored and are differently effected by dyes or stains. They are known as the entocuticle, also as the dermis or secondary cuticle. This is the laminate elastic portion. The surface of the cuticle or exocuticle may be smooth, polished, wrinkled, striate, granulate, tuberculate, or rugose. The sculpturing of the cuticle is frequently used in differentiating species.

Chitin.—The hardness and density of the cuticle is due to the deposition within it of a horny substance known as chitin. This substance is but little effected by ordinary acids or alkalies and

can not be identified with the microscope. The chitin is limited to the exocuticle and its presence is the reason for the inelasticity. The absence of chitin in the entocuticle permits of the elasticity of this layer.

Hypodermis.—The single layer of cells adjacent to the ental surface of the cuticle is the hypodermis. The cells are frequently more or less cubical in outline but may be thin and pavement-like in form. Each is provided with a nucleus. The cell-walls are sometimes obscure or wanting so that the cells form a syncitium. The cuticle is formed as a fluid excretion from the hypodermal cells or as a direct modification of the peripheral ends of the cells themselves. The hypodermis is the active, living part of the body-wall. It is a direct derivative from the ectoderm, one of the germ layers.

Basement Membrane.—The delicate hyaline structure covering the inner ends of the hypodermal cells is the basement membrane. It is more easily identified where it has been separated from the hypodermal cells or in species where the ends of the hypodermal cells adjacent to the basement membrane are constricted.

Cuticular Appendages.—The ectal surface of the cuticle is frequently irregular through its production into long or short cone-like projections of varying sizes. Such projections are extensions of the body-wall, are lined with hypodermis, and are generally designated as spines. They should not be confused with the true appendages of the cuticle, the setae and the spinulae.

Seta.—Each of the hair-like appendages borne on the surface of the cuticle is known as a seta. It is hollow, frequently open at the distal end, and is formed by a special cell of the hypodermis which is oval in outline and several times the size of the adjacent cells. This is known as a trichogen cell. The setae vary in size from minute microscopical projections to large spine-like protuberances which frequently are incorrectly designated as spines. An examination of a section of the body-wall through a seta shows that it consists of four parts: the trichogen cell adjacent to the hypodermis; the pore-canal or trichopore, an opening through the cuticle connecting with the lumen of the hair-like portion of the seta; the shaft, the hair-like portion projecting above the ectal surface of the cuticle; and the calyx or cup in the ectal surface of the cuticle in which the shaft is inserted. The calyx, the alveolus of some authors, appears as a depressed circle when the shaft is in place and its presence is the only certain external character for the identification of a seta. The punctate appearance of the surface of the cuticle is frequently due to the presence of numerous calyces. The setae are usually simple, greatly elongated conical projections,

but the shaft may be twisted or branched, forming irregular or plumose setae. The shaft may be greatly flattened forming scales which may be entire or notched at the distal end. Where the surface is densely covered with setae, it is said to be setiferous, not setaceous. The seta is sometimes borne by a pimple-like swelling of the body-wall, a chalaza.

Draw a portion of a section of the body-wall of an insect through a seta and a trichogen cell and name the parts.

Spinula.—The ectal surface of the cuticle or of the exocuticle bears in addition to the setae other hair-like appendages, which are known as spinulae. These structures are similar in general appearance to the setae, are of common occurrence, particularly on the wings, antennae, and cuticular lining of the prepharynx. The spinulae can always be differentiated from the setae from the fact that they lack a calyx and, therefore, never show a depressed ring about their proximal end. They are never associated with trichogen cells, vary considerably in form, and are also known as cuticular nodules, solid hairs, fixed hairs, and aculeae.

Draw a portion of the surface of a wing of an insect showing setae and spinulae.

EXOSKELETON.—The outer covering or cuticle is known as the exoskeleton. The chitin is not uniformly distributed throughout the cuticle, if it were, the body of an insect would be like an unjointed armor, incapable of movement in any direction. Its body, on the other hand, is capable of movement in practically any direction. The result of this movement has been the production of a large number of flexible lines, bands or areas, in which only a limited amount of chitin has been deposited, even in the exocuticle. Sections of the body-wall through such flexible lines or bands show that the cuticle is of practically the same thickness where the flexible lines occur as on either side of them.

Membrane.—The broad flexible areas of the cuticle, as for example the delicate connecting parts between the head and thorax or the irregular folds or areas articulating the legs to the thorax, which are composed of exocuticle and entocuticle, are generally indicated as cuticular membrane. In the following pages they are simply designated as membrane or coria.

Coria.—The bands of membrane, as the flexible lines between the abdominal segments and some of the thoracic segments, are known as coriae, also as conjunctivae or intersegmental membranes. In the cases named, the union between the segments is a transverse one and the connecting membrane between two such segments is known as a segmacoria. The different regions of the same or

several adjacent segments may be separated by bands of membrane that are parallel to the long axis of the body and since these bands are usually located on the lateral aspect of the body, they are known collectively as the lateral coria. The membrane forming a part of the articulation of the various appendages is also known as a coria, as that articulating the legs, the coxacoriae.

Suture.—There are in addition to the broad bands of membrane just described, the coriae, flexible areas of membrane which are mere lines. Such a line-like area is known as a suture. The distinction between a suture and a coria is not sharply defined. A suture, as here defined is probably only a coria that has been greatly reduced by the gradual extension of the chitinized areas which it connects. The primitive suture always consists of a narrow area of membrane, which would suggest that the membrane provides for more or less movement or flexibility. For this reason such sutures are sometimes known as movable sutures in contradistinction to fixed sutures, where the flexibility has been lost by the complete chitinization of the membrane or the fusion of the two sclerites on the two sides of the suture. Movable sutures are more characteristic of generalized insects. The fixed sutures can usually be identified as slight furrows extending across the ectal surface of the cuticle. Such furrows are sometimes replaced by fine line-like ridges or may be completely effaced from the ectal surface, when the sutures are said to be obsolete. The position of fixed and sometimes of obsolete sutures can be determined by the presence of a thin plate along the ental surface of the cuticle where the suture should be located. The ectal surface of the cuticle is frequently marked by furrows and ridges identical in appearance to movable sutures and coriae. These are known as secondary sutures. It is impossible to determine from an external examination which are true coriae or sutures and which are furrows, ridges, or secondary sutures. This can be decided only from a study of the position of the sutures in generalized insects, a comparison between these and the insects showing an intermediate stage of modification, and the species in hand.

There is frequently necessity for differentiating between the various coriae and sutures. In the case of the segmacoriae or those between the segments, this can be accomplished by adding the prefix of the name of the segment forming its caudal limit. The coria cephalad of the prothorax is the procoria, that cephalad of the mesothorax the mesocoria, of the metathorax the metacoria, of the first abdominal segment the unacoria, of the second abdominal segment the duacoria. The coria surrounding the articulation of

each antenna is in antacoria, around each leg a coxacoria, and around each metathoracic leg a metacoxacoria. The coriae are frequently wholly or in part reduced to sutures. In such cases a similar nomenclature can be used, thus: prosuture, mesosuture, metasuture, unasuture, coxasuture, etc.

Animals in the course of their descent or evolution have been modified from the primitive stock. Those that retain most or several of the characters of their ancestors or resemble them most closely are said to be generalized. On the other hand those that have either lost many of these structures and features of their ancestors or retained them in a greatly modified form, have departed far from their ancestors. Such animals are said to be specialized. These are comparative terms. A very generalized animal may be specialized in certain features while a very specialized animal may have one or more generalized structures. The condition of the coriae and sutures offers excellent indices for determining the amount of specialization occurring in insects.

Sclerites.—The dense opaque chitinized areas connected by coriae or sutures are known as sclerites. While the coriae and sutures are a direct result of the movement of the body of the insect, the sclerites have arisen through the necessity for inflexible areas for the attachment of muscles and the protection of the internal organs. The sclerites vary in size from a large area, as a tergum of an abdominal segment, to minute areas in the head and thorax. Adjacent sclerites frequently become united by the obsolescence of the separating suture. In differentiating the parts of the cuticle, the names are applied to the sclerites and not to the sutures. It is sometimes desirable to designate a particular suture, and in such cases this is usually done by combining the names of the adjacent sclerites. The suture between the front and clypeus is known as the fronto-clypeal suture, that between the front and gena as the fronto-genal suture. In generalized insects the amount of membrane surrounding the sclerites is sometimes considerable so that the suture may be broad and distinct. When insects become specialized, the width of the coria is greatly reduced and the sclerites are almost adjacent and closely compacted. Some of the sclerites have lost their chitinization so as to allow movement in certain directions, hence are membranous like their bounding coriae. Such membranous sclerites are indistinguishable from the coriae, but should be named regardless of the fact as to whether they are strongly chitinized or not.

Articulation.—The abdomen is divided into a series of similar regions or segments. It is a common practise among students of

insects to designate such subdivisions as joints. In a similar manner the subdivisions of the antennae and legs are also frequently designated as joints. The place where two subdivisions of an appendage are adjacent, should be designated as a joint, while the portion between two joints, that is an internode, should be designated as a segment. These terms are applied in this way on the following pages. The segments of the appendages, particularly those of the legs and mouth-parts, have more or less globular enlargements or concave depressions at their point of articulation. The point of articulation upon the body is known as a coila and the point of articulation upon an appendage is known as an artis. The terms acetabulum and condyle are not practical for use with insects. With the mandible the acetabulum is usually located upon the head and the condyle upon the appendage, but with the legs this condition is reversed and the condyle is located on the body and the acetabulum on the appendage. The term coila is always applied to the bodyside of the articulation regardless of whether it is a condyle or an acetabulum, while the term artis is applied in the same way to the appendage-side of the articulation.

Endoskeleton.—The body of an insect does not have a true internal skeleton. The term endoskeleton is applied to the chitinous projections found on the ental surface of the cuticle or exoskeleton. These are produced as infoldings or ingrowths of the exoskeleton for the attachment of muscles and the stiffening of the exoskeleton. Such infoldings are found on each of the three body regions, head, thorax, and abdomen, and originate either as invaginations of the ectoderm or body-wall during embryonic development or as invaginations or infoldings during nymphal and pupal development. The projections of the endoskeleton, while similar in appearance, may be very different in origin. Some bear a definite relation to the segment in which they are located, while others have been developed secondarily for a particular purpose.

Apodeme.—The great majority of the projections of the endoskeleton are primary in origin and such projections are known as apodemes. The number of apodemes and their point of invagination or attachment is characteristic for a segment. The apodemes of the dorsal part of the body are known as dorsal apodemes, those of the lateral part as lateral apodemes, and those of the ventral part as ventral apodemes. The apodemes of the head are known collectively as the tentorium, the lateral apodemes of the thorax as apodemes or pleurademae, and the ventral apodemes as apophyses or furcae and furcella. The point of attachment of an apodeme is usually indicated on the ectal surface by a trumpet-shaped open-

ing, a pit, a furrow, a slight swelling, or a ridge. When the external opening is prominent, there is often a cavity which extends for some distance into the apodeme. The point of origin of an apodeme or its place of attachment is frequently of great importance in determining the homology of the adjacent sclerites.

Parademe.—The name of parademe is given to those parts of the endoskeleton which are developed secondarily and like the apodemes serve for the attachment of muscles. They are also known as implexes or endoplicae. The parademes vary greatly in size and are usually developed as an infolding of the edge of a sclerite or from the ental surface of a suture. They reach their greatest development in the tergum of the thorax, where each is known as a phragma. In some cases they are developed as long slender arms similar in appearance to the apodemes, from which they can be distinguished only by their point of origin. They frequently have external openings similar to those of the apodemes.

The place on the ectal surface of the cuticle where an apodeme or a parademe has been invaginated is named by adding the postfix ina to the name of the apodeme or parademe. The point of invagination of a furca is a furcina, of a pretentorium is a pretentorina, of a phragma is a phragmina.

Lamella.—The two margins of adjacent sclerites are frequently infolded and by the fusion of these infoldings a plate is formed along the ental surface of the suture. Such a plate is known as a lamella. The ectal surface of a sclerite may be deeply furrowed and the cuticle on the ental surface of the bottom of the furrow may extend entad plate-like, forming a lamella similar in appearance to that formed at a suture. The depth of the lamella is usually not great, but its length may be considerable. The lamellae are parademes.

Spiracles.—The openings in the lateral aspect of the external cuticle through which the insect respires are known as spiracles. They are always arranged in pairs and, with the exception of a single genus, are confined to the thorax and abdomen. There are never more than ten pairs in adult insects and the number may be reduced to a single pair. In a few insects all the spiracles are wanting and respiration takes place directly through the cuticle. There are two pairs on the thorax, one located in or near the mesocoria, the mesospiracles, which belong to the mesothorax. They sometimes migrate onto the prothorax in which case they are sometimes incorrectly considered as belonging to the prothorax. The second pair of spiracles, the metaspiracles, are located in or near the metacoria and belong to the metathorax. The remaining eight pairs

belong to the abdomen and are known as the abdominal spiracles. They are situated on segments one to eight. Those of the eighth segment, particularly in larvae, sometimes migrate caudad onto the ninth segment. The abdominal spiracles can be differentiated, when necessary, in the same way as the transverse coriae, thus: unaspiracles, duaspiracles, trespiracles, etc. They are generally not so persistent as the thoracic spiracles. When some are wanting, it is usually one, two, or more of the caudal pairs; one or two of the cephalic pairs; or some of the pairs from each end of the abdomen.

Nomenclature.—The names applied to the various sclerites of insects are the result of the labors of two classes of students, systematists and anatomists. The systematists as a class have often unfortunately not been well informed on the anatomy of insects, but have made numerous errors in the identification and homology of the sclerites. They have made practically no effort to unify their nomenclature and some have even believed that there should be a distinct terminology for each order. The result has been the production of a considerable number of names which in many cases are applicable only to a single order of insects. These names constitute an integral part of the voluminous literature of the past one hundred and fifty years. The insect anatomists on the other hand have as a rule not been interested in the detailed classification of insects and apparently have been more or less ignorant of the nomenclature of the systematists. Careful detailed studies of the external anatomy of insects of the greatest importance have been made, but unfortunately there is a certain amount of disagreement even among the anatomists as to what names should be applied to certain sclerites. The selection of a set of names that would meet the approval of all classes of students would be impossible. An attempt has been made to adopt a nomenclature that would conform as nearly as possible with the views of the morphologists and still be consistent with that used by the systematists. Due weight has been given to the opinions of the insect-anatomists but freedom of decision has been reserved in every case in an endeavor to produce a standard nomenclature applicable to all the sclerites of all the orders of insects. Many new terms or names occur on the following pages. These are in most cases applied to structures, parts, or conditions not hitherto named.

The omission in the descriptions of the various species of any reference to the presence or form of any named structure or area should be interpreted in every case as an indication that the structure has not been identified. This may have been due to the

fact that the structure was obsolete or wanting or that it could not be found.

Systematists and writers upon the anatomy of insects frequently use the prefix sub in the sense of somewhat. They apply it to adjectives to qualify their meaning, thus, subangular is somewhat angular, subelongate is somewhat elongate, and subparallel is somewhat parallel.

Words indicating length, except in the case of the appendages, are used in the following descriptions with reference to the entire length of the body and not applied to the part described, that is, they are always parallel to the meson; while words indicating width are used with reference to measurements extending from side to side, perpendicular to the meson. This applies not only to chitinized plates, but to sutures and coriae.

Specimens.—An effort has been made in selecting species for description, except in the description of wings, to choose not only those species that are easily obtainable and easily identified but also those that would fit well in a series showing different stages of modification of the various structures. It will be found in many cases that other species of the same genus and in some cases species of the same family will answer equally well for the species described and named. This has not been practical in selecting examples to show the modifications of the veins of the wings, because it is necessary in such a study to use those wings showing a generalized condition, such species are generally rare and inaccessible except in large museums. An effort has been made to overcome this difficulty by figuring the wing of each species described. Specimens of several of the species or of closely related species can be obtained from European dealers in insects, while specimens of all the species used for the other anatomical parts can be obtained from American dealers.

While many features of the external anatomy can be determined from an examination of pinned or alcoholic specimens, all the characteristics can only be identified on specimens that have been cleaned in a solution of caustic potash. The dried specimens have the delicate membranous parts shrunken and out of shape, they as well as the alcoholic specimens generally have the surface of the cuticle covered with grease and dust, which conceal the finer sutures. A ten per cent solution of caustic potash answers best for this purpose. The parts to be studied should be removed and placed in a cold solution and allowed to remain until all the muscles and internal organs are destroyed, usually requiring about twenty-four hours. Where the parts are thin and delicate, a five per cent or

weaker solution should be used or the specimens left in the ten per cent solution for a shorter length of time. If pinned or dry specimens are used, they should be boiled in water before being placed in caustic potash. Just as perfect preparations can be made from dried specimens as from those that have been preserved in alcohol. Heat is frequently used in cleaning specimens with caustic potash. While the specimens can be prepared in a much shorter time in this way, the heat, except in the case of very heavily chitinized parts, will distort the specimens unless care is used. Upon removal from the caustic potash the specimens should be thoroughly washed in distilled water and placed in seventy per cent alcohol for a short time. If the specimens are to be studied as dry preparations, they should be placed in ninety-five per cent alcohol for twenty-four hours to harden them. However, much better results will be obtained, if the preparations are studied in seventy per cent alcohol in a Syracuse watch-glass. If a weaker solution of alcohol or water is used, the preparations will float. The specimens need to be completely covered with alcohol. There is frequently difficulty in keeping specimens in place so that a particular surface can be studied. This can be accomplished by placing two or more small pieces of a thick microscopic slide or of a thick plate of glass in the watch-glass and wedging the specimen into place between them. It is sometimes desirable to have the specimens cleared so that the outer parts are semitransparent. Such specimens should be thoroughly dehydrated in ninety-five per cent alcohol and cleared and studied in carbol-xylol. This solution is made by combining one part by measure of the melted crystals of carbolic acid with three parts by measure of xylol. The preparations can be studied in this solution in Syracuse watch-glasses and should be stored in vials in carbol-xylol. When the solution in the watch-glass evaporates so that crystals are formed, xylol should be added. An ordinary gooseneck electric drop-light equipped with a fifty watt lamp will be found very serviceable in the following studies.

In making preparations to show the endoskeleton, the specimens, after they have been clarified with caustic potash, can be cleaned by the use of an artist's sable brush with less danger of breaking the more delicate parts. If a specimen needs to be cut or divided, this should be done before it has been placed in caustic potash. Many of the delicate structures can be identified more easily if they are stained with a dye that will color the cuticle. Gage's Säurefuchsin gives excellent results. It is made as follows:

Säurefuchsin	0.5 gr.
Hydrochloric acid, 10 per cent	25.0 cc.
Distilled water	300.0 cc.

The specimen to be stained should be thoroughly washed in distilled water before it is placed in the stain. The excess of stain should be removed with distilled water. In case of overstaining, the stain can be removed with a dilute solution of caustic potash.

METHODS.—The successful study of the external anatomy of insects requires good dissections and mounted preparations of the parts to be examined. Many dissections require considerable time to prepare, so much time in certain cases that it is not practical to expect a student to make them. A study of the external anatomy may have as its aim the study and drawing of a considerable series of species or the examination of a limited number of species and the acquisition of skill in the making of the preparations used in such an examination. The amount of time that can ordinarily be devoted to insect morphology is so little, that, if the student is to acquire any breadth of view, there will not be time for him to make his own preparations. These should be prepared beforehand by the instructor. The preparations should be of such a character as to show exactly what the student should find. They should be kept in good condition in well labelled vials. The mental attitude of the student toward his studies and the neatness and efficiency of his work are in direct proportion to the kind of preparations and material furnished and the attention given him by the instructor.

DRAWINGS.—The only way in which an instructor can know whether the student has identified the parts of a preparation correctly and observed accurately their shape, is by drawing the preparation and identifying the parts on a drawing. The drawing should be an outline drawing. The addition of shading, as a rule, obscures the details and conceals inaccuracies in observation. It is of great advantage for the sake of comparison if all the drawings of the same structure of different species are all drawn to the same size regardless of the variation in size of these parts in different insects. The body and its regions should be drawn with the head to the left or with the head at the top of the page. The head when drawn separately should be shown with the mouth toward the bottom of the page and the cephalic end of a thoracic or abdominal segment to the left. The appendages, including the antennae, mandibles, maxillae, labium, and legs should be drawn with their attached or proximal end at the left or at the bottom of the page, and the wings with their attached or proximal ends at the left. The outline of the drawing and all sutures should be represented by continuous lines. The coriae and areas of membrane about and between sclerites should be bounded by continuous lines and the surface coarsely stippled. The outline of structures

below the surface should be indicated by dotted lines. The surface of the sclerites are frequently traversed by furrows and ridges, the position of which it is desirable to show on the drawing. The ridges should be indicated by a broken line or a series of dashes and the furrows by a line consisting of alternate dashes and dots. The sclerites are sometimes partially or entirely divided by suture-like lines, the secondary sutures. These should be indicated by a line consisting of alternating dashes and dots. The outline of all openings through the body-wall, as the foramen, should be bounded by a continuous line, and the fact that it is an opening indicated by a series of oblique parallel continuous lines. The student should provide himself with good, white or blue-white, not cream-white or yellow-toned, linen ledger paper that weighs about twenty-eight pounds to the ream. It should be cut in pieces preferably $8\frac{1}{2} \times 11$. Many students do not have any facility in the handling of a pencil. This can be overcome in great part if the instructor will give such students special attention when they make their first drawings.

CHAPTER II

FIXED PARTS OF THE HEAD

The fixed parts of the head of an insect can be divided into two groups, the external skeleton or exoskeleton and the internal skeleton or endoskeleton. The exoskeleton forms a cuticular box or skull consisting in most insects of several sclerites separated by indistinct sutures. These sutures can be traced in generalized insects but with specialization the number is reduced until a stage is reached where the head apparently consists of a single piece. There is articulated to the head-capsule a number of movable appendages, a pair for each segment. The obsolesence of sutures and the consequent union of sclerites is due in great part to the modification in form of the movable appendages or mouth-parts, their transformation from organs for cutting and chewing into organs for sucking. The sclerites of the head are of two kinds, the paired sclerites which are located one on each side of the meson, and the unpaired sclerites which are located on the meson.

The endoskeleton consists of a series of chitinized props that extend from the region adjacent to the mouth and the foramen to the ental surface of the exoskeleton. These props are known collectively as the tentorium and serve not only for the attachment of muscles but to support and strengthen the external skeleton. The exoskeleton or head-capsule consists of the following parts:—

Foramen.—The opening in the head-capsule, (Fig. 2, *of*) through which the alimentary canal and other organs pass is the foramen. It is connected with the thorax by an area of membrane known as the cervix, which is the segmental part of the labial segment of which the labium is the appendage. The foramen is also known as the foramen magnum or occipital foramen. In generalized insects the foramen is large and the sclerites limiting it are distinct, but in specialized insects the size of the opening is greatly reduced and the sutures bounding the limiting sclerites are obsolete.

The foramen varies greatly in form, position, and structure according to whether the head is hypognathous, vertical with the mouth directed ventrad, or prognathous, horizontal with the mouth directed cephalad. The topography of the head found in gen-

eralized insects shows conclusively that the hypognathous type is the most primitive and the prognathous the most modified. There are four conditions of the foramen found in insects, the orcephalic type, the decephalic type, the plecephalic type, the cocephalic type, and the melocephalic type. The head in the orcephalic type is hypognathous and the foramen is divided into two parts by the corpotentorium, a ventral neuraforamen (Fig. 2, *nrf*) and a dorsal alaforamen (Fig. 2, *acf*). The latter is separated from the dorsal end of the head by the vertex and occiput. The decephalic type differs from the orcephalic type only in that the head is prognathous. The plecephalic type is also prognathous and while the neuraforamen is on the ventral aspect, the alaforamen extends from the ventral to the caudal aspect and is at the opposite end of the head from the mouth. The decephalic and plecephalic types mark successive stages in the migration of the foramen to keep pace with the modification of the head necessitated by its change from a hypognathous to a prognathous condition. The culmination is reached in the cocephalic type where the foramen is limited to the end of the head opposite the mouth and where an alaforamen and neuraforamen can not be identified on the external surface. In certain insects of the cocephalic type, while the foramen retains the position characteristic of this type, the cephalic part of the head is bent in such a way as to appear as if hypognathous. Such heads are pseudohypognathous and belong to the melocephalic type.

Cervacoria.—The cephalic membranous end of the cervix (Fig. 2, *cc*) is attached to the walls of the head near the foramen. This portion of the cervix is the cervacoria. It is always important to identify the exact line of attachment of the cervacoria, since this decides what structures in this region belong to the exoskeleton and what to the endoskeleton.

Mouth.—The opening surrounded by the mouth-parts between which the food finds entrance into the prepharynx, the cephalic end of the alimentary canal, is the mouth. Its exact position and external form is indefinite, due to its being surrounded by mouth-parts which vary considerably in form. In some sucking insects the mouth does not appear to be located upon the head itself. The mouth may be directed ventrad, the head hypognathous, or cephalad, the head prognathous. There is correlated with this difference in direction, a corresponding shifting in the position of the foramen. The buccal cavity or mouth-cavity is a part of the pharynx and the term mouth is limited to the orifice at which food is taken into the body. In the following descriptions and listing of the parts of the head, the mouth has been considered as directed

cephalad or prognathous. The heads of the insects have been described, however, from the natural position.

Compound Eyes.—The convex or globular swelling located on each lateral aspect of the head is a compound eye (Fig. 2, *ce*). Each is considered by some writers as a true appendage from its stalked condition in certain Crústacea and by others as only a modified portion of the head-capsule. They are named compound eyes from the fact that each is composed of a large number of subdivisions. Each of these subdivisions is hexagonal in outline and is known as an ommatidium. It was designated as an ocellus by earlier writers. The hexagonal ectal surface of each ommatidium is known as a facet. Functional compound eyes are peculiar to adults and nymphs of the Exopteraria and to the adults of the Entopteraria.

Epicranial Suture.—The inverted Y-shaped line located on the dorsal aspect of the head is the epicranial suture. The stem of the Y originates at the foramen and extends along the dorso-meson for some distance, where it forks and each arm extends toward a

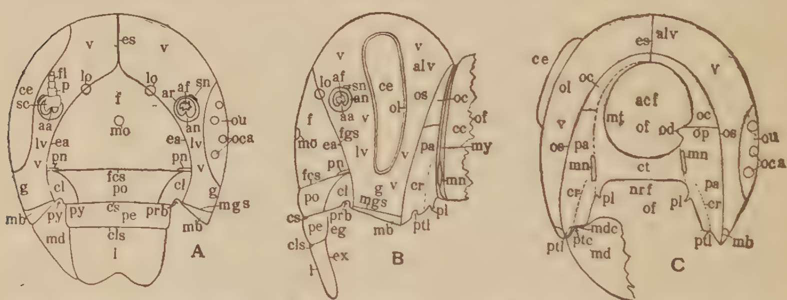

Fig. 2.—Hypothetical head. A, dorsal aspect; B, lateral aspect; C, ventral aspect.

compound eye in adult insects and to the cephalic margin of the head in larvae. The stem (Fig. 2, *es*) is known as the epicranial stem, midcranial or coronal suture and each arm (Fig. 2, *ea*) as an epicranial arm or frontal suture. The epicranial suture marks the line of closure of the head-capsule during embryonic development. It is generally complete in nymphs and larvae, also in some generalized adult insects. The epicranial stem is frequently indicated in adult insects of the Exopteraria, but is wanting in most adult insects of the Entopteraria. In this latter group the epicranial arms are frequently present, while in the former group they are either wanting or considered as identical with the fronto-genal sutures.

Vertex.—The portion of the head extending from near the

foramen to the arms of the epicranial suture, bearing the compound eyes, and extending onto the ventral aspect to the sutures marking the extent of the sclerites of the ventral aspect, is the (Fig. 2, *v*) vertex. It generally bears the lateral ocelli, frequently also the median ocellus, and the antacoriae; and is not only the most important but usually the largest sclerite of the head. The vertex is divided into two portions by the stem of the epicranial suture and is, therefore, a paired sclerite, but this suture is completely wanting in all but generalized insects. It is also known as the parietals and a portion between the median ocellus and the front as the postfrons. Since the vertex occurs upon such different aspects of the head, its various parts have been designated to differentiate them. None of these various parts of the vertex are bounded by sutures. While all the following named parts are considered as subdivisions of the vertex, the term vertex is used in two senses, for the region between the compound eyes and the entire area, but primarily to designate the portion of the head upon the dorsal aspect. The portion upon the ventral aspect is known as the (Fig. 2, *alv*) alavertex. This region is almost universally incorrectly designated by systematists as the occiput. The portion of the vertex located between a compound eye and a mandible is universally known as a gena. When the vertex is reduced to a narrow linear area between the front and a compound eye, this area is known as the (Fig. 2, *lv*) linavertex, also as a parafrons. Where the vertex is divided into two parts by the fusion of the mesal margins of the compound eyes, the cephalic portion is known as the prevertex and the caudal portion as the postvertex.

Orbits.—The narrow portions of the vertex adjacent to the margins of the compound eyes are known as the orbits. They are here described as if the head were hypognathous. The region adjacent to the mesal margin of the cephalic aspect of a compound eye is known as a facial orbit, also known as an anterior or frontal orbit. The margin adjacent to the dorsal aspect as a vertical orbit, also known as a superior orbit. The region adjacent to the mesal or lateral margin of the caudal or lateral aspect is an occipital orbit, also known as a posterior orbit. The region adjacent to the ventral margin is a genal orbit, also known as an inferior orbit or malar space.

Front.—The unpaired subtriangular sclerite located cephalad of the arms of the epicranial suture and vertex (Fig. 2, *f*) is the front. Its cephalic boundary is usually a distinct transverse suture. The front bears the median ocellus and sometimes the lateral ocelli. When the epicranial suture is obsolete, the area between the com-

pound eyes is often designated as the front. It is also known as the frons or clypeus posterior or antefrons. When the sutures separating the front, clypeus, and labrum are obsolete, the entire area has been called the epistoma.

Gena.—Each lateral portion of the head located between a compound eye and a mandible (Fig. 2, *g*) was designated by the older writers as a gena, also known sometimes as a parafrons. It is not completely bounded by sutures even in generalized insects and must be considered as a term indicating a certain region of the head-capsule and not as a distinct sclerite. In generalized insects each gena is separated from the front by a distinct longitudinal suture, a fronto-genal suture or epicranial arm. This term should be limited in its use to adult insects and applied only to the region cephalad of the compound eyes. The genae often offer characters of great taxanomic value and the term should be retained. It is also known as the malar space. They are a part of the vertex.

Fronto-genal Suture.—The longitudinal suture (Fig. 2, *fgs*) that forms each lateral boundary of the front in generalized insects and separates it from a gena on each side, is known as a fronto-genal suture, apparently also as a paracephalic or laterocephalic suture. This suture originates adjacent to the cephalic end of the compound eyes and is present only in certain adult insects of the Exopteraria. The fronto-genal sutures are here considered as the equivalent of the epicranial arms.

Antacoria.—The narrow ring of membrane (Fig. 2, *an*) connecting each antenna with the head is an antacoria, also as a basantenna. This ring of membrane, although usually narrow, is generally distinct. When an antenna is removed, there is a hole left in the antacoria. This hole, an antafossa, which is an artifact, is usually designated as an antennal fossa or antennal socket. In larvae the antacoriae are located in the vertex and in generalized adult insects in the vertex or the front. If the fronto-genal sutures are considered as continuations of the arms of the epicranial suture, the antacoriae would have to be considered as located upon the front, the sutures always passing laterad of the antacoriae. The antacoriae vary considerably in position, due probably to their migration along the epicranial arms.

Antennaria.—There is in generalized insects a small annular sclerite (Fig. 2, *ar*) forming the periphery of each antacoria. This sclerite is the antennaria. Each is also known as an antennal sclerite or antennale.

Antacoila.—Each antennaria bears a projection, frequently triangular in outline, against which an antartis articulates. This

projection is an antacoila (Fig. 2, *aa*), also known as an antennifer.

Antacava.—The antennae are sometimes articulated to the head-capsule at the bottom of deep sockets. The antacoria, antacoila, and antafossa of each antenna, are located at the bottom of the socket. Such a socket is an antacava.

Antennal Tubercle.—The body-wall of the head is sometimes produced into two prominent subconical projections, each of which bears an antacoria, an antennaria, and an antenna. These projections are known as antennal tubercles.

Oculata.—The narrow ring-like area surrounding each compound eye and separated from the vertex in generalized insects by a fine suture is an (Fig. 2, *ol*) oculata. The ental surface of this sclerite is frequently produced into a prominent ring-like plate or parademe extending into the head-cavity. Such a parademe is also known as an oculata.

Ocelli.—The head bears three simple eyes or ocelli, arranged in the form of a triangle, the apex of the triangle directed toward the mouth. The ocellus forming the apex of the triangle is always located on the meson of the front in generalized insects. It is known as the median ocellus (Fig. 2, *mo*). Each of the other ocelli is known as a lateral ocellus (Fig. 2, *lo*). They are usually located upon the vertex but may be located upon the front. The three ocelli are usually placed near together in the Entopteraria and located on the vertex while in a few adult Exopteraria they are all located upon the front. Functional ocelli are peculiar to adults of the Pterygota, possibly most nymphs of the Orthoptera, and Machilis.

Ocularum.—The compound eyes are wanting in larvae and are represented by one to several simple eyes known as ocellae, also known as ocelli. The ocellae are arranged on an area on each side of the head, usually differently colored or more elevated than the adjacent parts of the vertex (Fig. 2, *ou*), known as an ocularium.

Ocellae.—Simple eyes are found in several orders of insects. The ocelli just described are examples of one type, those of the other type are known as ocellae (Fig. 2, *oca*). They are always located on each side of the head where the compound eyes are ordinarily situated. The ocellae found in various taxanomic groups are distinguished as follows: in the nymphs and adults of Collembola, they are known as ocellalae, in the nymphs and adults of Exopteraria as ocellanae, in the larvae of Entopteraria as ocellarae, and in the adults of Entopteraria as ocellasae. They are also known collectively as the adaptive ocelli.

Clypeus.—The area borne at the cephalic margin of the front is the clypeus. It consists typically of four sclerites, two that are

unpaired, the postclypeus and preclypeus, and one that is paired, the clypealia. In the great majority of insects, adults at least, these four sclerites are fused into a single piece or the sutures are only in part indicated and the entire area in such cases is designated as the clypeus. This fused area is also known as the chaperon, clypeus anterior, epistoma, nasus, and prelabrum. In the heteropterous Hemiptera the cephalic end is known as the tylus.

Postclypeus.—The unpaired region (Fig. 2, *po*) attached to the cephalic margin of the front is the postclypeus. It is of common occurrence in immature insects, but is of less frequent occurrence in adult insects. When this area is present, the suture separating the front and postclypeus is frequently obsolete, but the area is readily identified because it is usually differently colored or its surface is differently sculptured from that of the front. It is also known as the first clypeus, postfrons, epistoma, supraclypeus, or nasus.

Preclypeus.—The transverse unpaired area borne by the postclypeus (Fig. 2, *pe*) is the preclypeus, anteclypeus, infraclypeus, or rhinarium. It is usually bounded on its cephalic margin by a distinct suture, the clypeo-labral suture, and is a distinct area even in immature insects. The preclypeus probably comprises the greater part of the area usually designated as the clypeus in adult insects. It is also known as the second clypeus.

Clypealia.—The clypealia (Fig. 2, *cl*) is the small subtriangular or quadrangular area located at each lateral end of the postclypeus. The clypealiae are present only in the heads of generalized larvae. Each is also known as an antecoxal piece of the mandible or as a paraclypeus or lateroclypeus.

Clypofrons.—The transverse line, apparently forming the caüdal limit of the clypeus on the external surface of the head in such insects as those of the genus Harpalus, is universally considered as the fronto-clypeal suture. If the head of such an insect, however, is soaked in caustic potash, the head can be spread apart along this line and the epicranial arms and the fronto-clypeal suture identified upon the surfaces of this separated invaginated portion. The line on the external surface of the head is not, therefore, the fronto-clypeal suture, not even a suture, but the line of closure or fusion of the two surfaces of the invaginated portion. This line and the invaginated portion is the clypofrons.

Precoila.—The articulation of each mandible on the dorsal aspect of the head (Fig. 2, *prb*) is a well marked emargination or acetabulum in each clypealia, when this sclerite is present, and may be known as the precoila. It is also known as a dorsal condyle or epicondyle. In generalized adult insects this acetabulum is located

in a lateral prolongation of the clypeus and it is believed that these prolongations represent the parts of the clypealiae that have become fused with the postclypeus and preclypeus to form the clypeus. The precoila is apparently always located on the postclypeus, when this area can be identified. The belief that the portion of the clypeus bearing the precoila is the clypealia is strengthened from the fact that in certain insects this prolongation is a separate piece. The artis (Fig. 2, *pg*) articulating in this coila is the preartis. The portions of the clypeus bearing the precoilae have been named the clypanguli.

Labrum.—The unpaired sclerite (Fig. 2, *l*) borne by the cephalic margin of the clypeus or preclypeus is a movable flap and is known as the upper lip or labrum, also as the hypostoma by dipterists and as the epistoma. It is not a true appendage. The area ventrad of the labrum (Fig. 2, *ex*) and frequently incorrectly so labelled, is the epipharynx.

Torma.—The small structure found at each lateral end of the clypeo-labral suture (Fig. 8, *tm*) is a torma. Each extends onto the ventral aspect where it is usually a much larger area and forms a primary part of the division between the epipharynx and epigusta. The tormae are of importance in identifying the suture separating the labrum and clypeus or preclypeus, the clypeo-labral suture. They are sometimes of such size as to project from the lateral ends of this suture and to be exposed externally.

Fronto-clypeal Suture.—The suture separating the front and clypeus or postclypeus (Fig. 2, *fcs*) is the fronto-clypeal suture or incorrectly known as the clypeal suture. When the fronto-clypeal suture is obsolete and the front and clypeus constitute a single area, this is known as the fronto-clypeus.

Clypeal Suture.—The suture separating the postclypeus and preclypeus (Fig. 2, *cs*) is the clypeal suture.

Clypeo-labral Suture.—The suture separating the clypeus or preclypeus and labrum (Fig. 2, *cls*) is the clypeo-labral suture or incorrectly known as the labral suture.

Mandibularia.—The small sclerite present in certain generalized insects, adults and nymphs and larvae, along the cephalic margin of each gena (Fig. 2, *mb*) and laterad of the clypeus may be known as a mandibularia. Each is also known as a trochantin of the mandible or basimandibula.

Mando-genal Suture.—The suture separating the mandibularia from the front and vertex (Fig. 2, *mgs*) is the mando-genal suture.

Odontoidea.—There is in most insects a triangular projection extends on each side into the foramen (Fig. 2, *od*) which is not

covered by the cervacoria. These projections serve as points of articulation for the sclerites of the cervapleura and are known as the odontoideae. In generalized insects the maxillariae bear the odontoideae.

Occiput.—The caudal part of the ventral surface of the head (Fig. 2, *oc*) adjacent to the foramen is the occiput, also known as the protocranium. It is crossed by the stem of the epicranial suture and divided into two parts. The occiput is located between the foramen and the alavertex and each lateral half is more or less triangular. The sutures bounding the occiput are usually obsolete so that it can not be completely separated from the vertex. It is limited in all cases to a narrow area near the foramen.

Postgena.—The cephalic part of the ventral surface of the head (Fig. 2, *pa*) on each side of the foramen is known as a postgena, also as a hypostoma. The postgenae are typically never connected and each is frequently triangular in outline. The sutures separating the occiput and postgena on each side are generally obsolete so that there is no way in which the limits of these sclerites can be determined. The portion of the head bounding the foramen dorsad of a transverse line drawn through the ventral margins of the odontoideae is considered in such cases as the occiput and the portion on each side ventrad of such a line as a postgena. While the postgenae are widely separated on the meson in generalized insects, they may be fused for some distance in specialized insects. This general region has been indefinitely named the trophifer.

Occipital Suture.—The suture forming the lateral boundary of the occiput and postgena of each side (Fig. 2, *os*) and separating them from the alavertex is the occipital suture. It is frequently wanting. The portion of this suture bounding a postgena is also known as a hypostomal suture.

Occipito-postgenal Suture.—The short transverse suture which separates the occiput and postgena of each side (Fig. 2, *op*) in certain insects is an occipito-postgenal suture. This suture is present in only a very few insects. It may be secondary in origin.

Genaponta.—In specialized insects where the mouth-parts are elongated, the postgenae are also frequently elongated. They extend mesad cephalad of the cervacoria until they meet on the meson and fuse. The bridge thus formed limits the cephalic extent of the foramen and is known as the genaponta. It is often incorrectly considered as a gula. The formation of the genaponta divides the cervacoria in this region into two parts, a foraminal portion, a foramacoria, adjacent to the foramen, and an oral portion, the menta-

coria, adjacent to the labium, and usually reduced to a suture, a mentasuture.

Maxaponta.—The proximal portions of the maxillae and labium, which are located between the postgenae, become so modified in certain Diptera that they are indistinguishable from the adjacent parts of the head. There is thus formed a bridge which limits the cephalic extent of the foramen and since this bridge is derived from the jaws, it is known as the maxaponta.

Maxacava.—When the postgenae are prolonged cephalad for some distance, their mesal margins distant, so that a depression or cavity of considerable size is formed between them and cephalad of the genaponta, this depression is known as the maxacava. The maxillae and labium are retracted into and fill the maxacava when the mouth-parts are in place.

Paracoila.—The articulation of each maxilla on the ventral aspect (Fig. 2, *pl*) is a distinct coila at the cephalic end of a maxillaria, when the maxillariae are present, otherwise on the cephalic margin of a postgena. This coila is a paracoila and the artis articulating against it is a parartis. The paracoila is usually condylar in form.

Epicranium.—The absence of the epicranial suture and most of the other sutures in the head of the May-beetle led Straus-Durckheim to consider the head of this insect as consisting of only a single piece. This single piece he named the epicranium. Later authors have applied this term in different ways. It is frequently confined to the dorsal portion of the head, but as used by writers on immature insects it is synonymous with the vertex. This term has no place in insect anatomy and has not been used in the following descriptions.

Crassa.—The linear thickening on each postgena, (Fig. 2, *cr*) extending caudad from the mesal side of the postcoila, is a crassa. When the occipital sutures are obsolete, the crassae may be of considerable size, but their relation to the postcoilae, which they serve to support, will always identify them and differentiate them from the occipital sutures. They are also known as the mandibular apodemes and have been sometimes mistaken for the occipital sutures.

Maxillaria.—There is in certain generalized insects along the mesal margin of the postgena and occiput of each side (Fig. 2, *my*) a pair of narrow ribbon-like sclerites, the maxillariae. They are also known as the maxillary pleurites or maxillifers. The maxillariae when present bear the odontoideae.

Postcoila.—The articulation of each mandible on the ventral

side of the head (Fig. 2, *ptl*) is usually in a well marked emargination or acetabulum in the cephalic margin of a postgena and is known as a postcoila, also known as a hypocondyle or ventral condyle. The position of the postcoila is of value in identifying the position of the postgena. The artis articulating in the postcoila is the postartis.

Gula.—The gula is a sclerite of the ventral aspect of the head of certain insects in which the head is typically prognathous. It is T-shaped, when fully formed, and bears the labium at its cephalic end. The stem of the T is known as the gular stem and the bar of the T as the gular bar or better pregula, sometimes incorrectly as the submentum. It has been quite frequently assumed that the gula resulted when the head changed from a hypognathous to a prognathous condition. As a result of this change it was believed that the labium and maxillae were pulled cephalad and the space between the two postgenae vacated by these mouth-parts was filled with membrane. The membrane in time became strongly chitinized, forming a sclerite, the gula. This sclerite is found only in three orders of Entopteraria, Coleoptera, Neuroptera, and Trichoptera, although often considered as present in several other orders. Since the maxillae are firmly articulated to the postgenae, it would not be possible for them to be pulled cephalad without also stretching the postgenae. The above theory as to the formation of the gula is discarded here as untenable and it is assumed that the gula is a modification of a genaponta. The gula is also known as the gular plate.

Gular Sutures.—The two longitudinal sutures bounding each gula, one located on each side, are known as the gular sutures. The presence and extent of the gula is wholly dependent upon the presence and extent of the gular sutures. These sutures mark the line of migration of the metatentorinae from the foramen toward the cephalic end of the genaponta. Since there is a great variation in the extent of this migration, there is a corresponding variation in the length of the gular sutures and, consequently, of the gula. A pregula is frequently never formed, because the metatentorinae only rarely reach the cephalic part of the genaponta. The gula is sometimes apparently wanting through the fusion of the two sides of the gula or of the two gular sutures, leaving only a single mesal suture exposed. In such cases the gula is infolded and concealed and the single suture is known as the midgular suture. The portion of a postgena along the lateral side of each gular suture has been named a paragula.

Tentorium.—The endoskeleton of the head is known collective-

ly as the tentorium. It consists typically of three pairs of arms. Two of these are invaginated from definite regions of the head-capsule. The position of these points of invagination is associated with certain appendages and sclerites and is of great value in determining their homology. The tentorium consists of the following parts:—

Metatentoria.—The arms of the tentorium invaginated on the ventral aspect of the head adjacent to the foramen and the articulation of the maxillae (Fig. 3, *mt*) are the metatentoria. They are also known as the posterior arms of the tentorium. The extent of each metatentorium along each side of the foramen is limited by the line of attachment of the cervacoria. The point on the ectal surface of the head where each metatentorium is invaginated (Figs. 2 and 3, *mn*) or where it is attached to the ental surface of the head-capsule is a metatentorina, also known as a gular pit. The portion of the metatentoria along the caudal margin of the foramen is sometimes produced (Fig. 3) into one or more cuticular tendons,

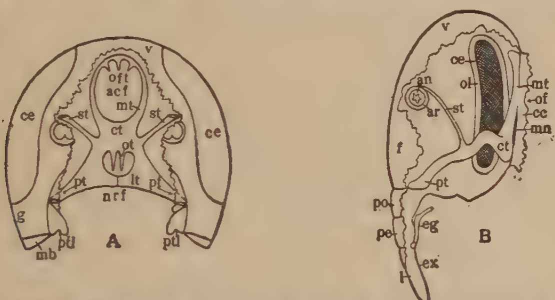

Fig. 3.—Hypothetical tentorium. A, ental surface of ventral aspect; B, ental surface of lateral aspect.

the formatendons. The mesal tendon is known as the dorsal apodeme and the lateral tendons as the tendons of the extensors of the head.

Pretentoria.—The arms of the tentorium invaginated on the dorsal aspect of the head (Fig. 3, *pt*) near the clypealia or precoila in generalized insects are the pretentoria. They are also known as the anterior arms of the tentorium. The point on the ectal surface of the head where each pretentorium is invaginated (Fig. 2, *pm*) or where it is attached to the ental surface of the head-capsule is a pretentorina or frontal pit. In specialized insects the pretentorinae are not fixed in position. They may migrate away from the precoila, but they are usually located on or near the epicranial arms.

Supratentoria.—Each supratentorium (Fig. 3, *st*) arises from the lateral margin of a pretentorium or of the corpotentorium and

extends either toward the front or the vertex, usually terminating near an antennaria. There is no embryological evidence to show that these arms are ever derived from external invaginations. In adult insects they are frequently slender thread-like arms, sometimes are largs arms, sometimes are wanting. Their apparent embryological history, their usual size, and their position suggest that they are not primary structures but off-shoots from the other tentoria, probably the pretentoria; but their presence in most orders of insects, their large size in widely separated orders, sometimes the largest of the tentoria, and their similarity in form and position shows them to be structures that are very old phylogenetically. The supratentoria are often not attached to the ental surface of the cuticle (Fig. 2, *sn*), when this attachment can be identified it is known as a supratentorina.

Corpotentorium.—In certain insects there is a prominent bridge which divides the foramen into two parts (Figs. 2 and 3, *ct*), the alimentary canal passing on one side of this bridge, the alaforamen (Fig. 3, *acf*), and the nervous system (Fig. 3, *nrf*) on the other, the neuraforamen. This bridge is known as the corpotentorium. It is formed from the fused ends of the pretentoria and metatentoria and is always concealed within the head. The corpotentorium is also known as the body of the tentorium. It may bear one or more tendons, the corpotendons.

Laminitentorium.—There is formed in a few insects another plate or bridge (Fig. 3, *lt*), which is connected with the corpotentorium, but is formed by a fusion of the cephalic ends of the pretentoria. It is known as the laminitentorium, also as the frontal plate of the tentorium. There is sometimes an opening left between the fused pretentoria, the caudal surface of which may contain one or more tendons, the oesotendons (Fig. 3, *ot*). The cephalic part of the laminitentorium may bear one or more tendons, the lamitendons.

1. EXOSKELETON

The forms selected for the study of the exoskeleton of the head are arranged in an ascending series. Those showing the most generalized condition are placed at the bottom of the series and are studied first. The succeeding forms are more and more specialized with the most specialized ones at the last of the series. The heads should be cleaned in caustic potash and studied in a Syracuse watch-glass in seventy per cent alcohol. They should be kept well covered with the fluid while in use. The appendages,

consisting of the mandible of one side, the maxillae, and the labium, should be removed.

Corydalus Cornutus.—The head of the larva of this insect is generalized on the dorsal aspect and specialized on the ventral. A study of the dorsal aspect is of particular importance in showing certain sclerites not found in adult insects. The mouth is prognathous and the head is strongly depressed and cocephalic. The fine line extending from the foramen along the dorso-meson to the cephalic third, where it forks and each branch extends toward the mouth, is the epicranial suture. The unbranched portion is the epicranial stem and each branch is an epicranial arm. Each arm extends cephalo-laterad from the meson for a short distance, then it curves and extends cephalad to a point midway between the curve and the cephalic margin of the head. At this point the arm bends abruptly laterad and the lateral portion curves gently cephalad to the cephalic margin of the head. The transverse suboval area on the dorsal aspect adjacent to the foramen and divided by the epicranial stem is the occiput. Its cephalic margin is elevated above the surface of the adjacent area. The large area located cephalad of the occiput and extending to the epicranial arms is the vertex. It is also divided by the epicranial stem. Each part covers a large portion of each lateral half of the dorsal aspect. It extends onto the ventral aspect, the alavertex, to the differently colored area on the ventro-meson. This mesal area is bounded on each side by a faint suture, a gular suture, the course of which will be described later. The caudal half of each lateral portion of the vertex is crossed by two curving ridges forming lateral teeth. The five sided area located caudad of an imaginary line connecting the points where the epicranial arms bend abruptly laterad, and enclosed on the other sides by the epicranial arms, is the front. The area located cephalad of the imaginary line marking the cephalic margin of the front is the postclypeus. Each lateral boundary is the faint suture which extends cephalo-laterad from the abrupt bend in the arm of an epicranial suture. It is similar in appearance to an epicranial suture and appears to be its direct continuation. The cephalic boundary is the line marking the division between the dark rugose area and the light colored smooth area. The fronto-clypeal suture is obsolete. The subtriangular area on each side enclosed by the cephalic end of an arm of the epicranial suture and the suture marking the lateral boundary of the postclypeus is a clypealia. Its cephalic margin forms a part of the cephalic margin of the head and is emarginate, forming a precoila. The transverse smooth area borne at the cephalic end of the postclypeus is the preclypeus. The

clypeal suture is distinct. The movable flap borne at the cephalic end of the preclypeus is the labrum. Its distal end bears two groups of long setae. There is on the cephalic margin of the vertex laterad of each clypealia a cylindrical brownish projection, an antennaria. It is separated from the vertex by a faint suture and its distal end bears a convex annular antacoria bearing an antenna. The convex area located caudad of each antennaria and bearing six or seven pearly disks is an ocularium. The pearly disks are ocellarae. The mesal end of the depression located on the transverse part of each arm of the epicranial suture is a pretentorina.

Draw the dorsal aspect of the head and name all the parts.

The meson of the ventral aspect adjacent to the foramen is squarely emarginate. There is a four-sided sclerite located in the emargination. This sclerite belongs to the cervix, it is the cervisternannum. From each lateral corner of this emargination there is a line-like suture, a gular suture, extends cephalad in a curving irregular course to the cephalic third of the head. At this point it bends laterad for a short distance and then cephalad to the margin of the head. The two sutures enclose an irregular T-shaped area, the gula. The transverse area at the cephalic end forming the top of the T is the pregula. Identify the depression in the transverse part of each gular suture. The mesal end marks the position of a metatentorina. The smooth subcrescent-shaped area situated at the lateral end of each depression of a gular suture is a postgena. Each caudo-lateral angle of the pregula rests upon a postgena. There is a paracoila located beneath this angle. The depression in the cephalic margin of each postgena is a postcoila. The furrow extending from the postcoila to the paracoila adjacent to the thickened cephalic margin is a crassa.

Draw the ventral aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

Blatta Orientalis.—The head, when held in the natural position, is bent back beneath the thorax and concealed. The mouth is consequently directed caudad instead of ventrad or cephalad. The head is considered as of the orecphalic type. The parts of the head have been described as if the mouth were directed cephalad. The blackish, reddish or yellowish in clarified specimens, more or less kidney-shaped granular area on each lateral portion of the head is a compound eye. The emargination is located on the mesal margin of the dorsal aspect. The narrow lighter colored marginal area surrounding each compound eye is an oculata. The large round whitish area of membrane adjacent to the emargination of each

compound eye is an antacoria. Each is enclosed by a chitinized ring, an antennaria, forming the peripheral margin of each antacoria. Each antennaria is dilated on the caudal side of the cephalic margin into a narrow sector-like projection, an antacoila, against which an antenna articulates. The caudal half of the dorsal surface is crossed by a Y-shaped whitish line, the epicranial suture. The stem of the Y originates at the foramen and extends onto the dorsal surface for a considerable distance, where it bifurcates and each arm extends obliquely toward an antacoria and ends in a smooth pale spot. Each of these spots is a lateral ocellus. The much smaller reddish spot cephalad of each lateral ocellus and adjacent to an antacoria has been described as one-half of a median ocellus. These reddish spots are muscle impressions, the median ocellus is wanting. The area located on the caudal and dorsal aspects and extending from near the foramen to the epicranial arm is the vertex. It is divided on the dorso-meson by the epicranial stem and each half extends onto the ventral aspect to the longitudinal fine ridge or suture, the occipital suture, located midway between the compound eyes and the foramen. The sclerite situated on the cephalic side of the epicranial arms is the front. This sclerite surrounds the antacoriae. The cephalic half of the front extends laterad to the sutures, the fronto-genal sutures, extending from between the meso-cephalic portion of the compound eyes and the antacoriae toward the cephalic margin of the head. The cephalic half of each of these sutures extends cephalo-mesad and ends in a minute blackish or brownish area. The suture forming the cephalic boundary of the front, the fronto-clypeal suture, is obsolete for the greater part of its course. Note the emargination in the lateral margin of each of the brown or blackish thickened areas. Each is a precoila. The fine furrow forming the caudal border of the area bearing a precoila is a lateral portion of the vestigial fronto-clypeal suture. Each portion of this suture marks the position of a pretentorina. The area laterad of each fronto-genal suture and cephalad of each compound eye is a gena. The small triangular area on each lateral aspect located cephalad of a gena and the cephalo-lateral part of the front and extending mesad to a pretentorina is a mandibularia. The area located cephalad of the imaginary line connecting the vestigial parts of the fronto-clypeal suture is the clypeus. The precoilae are borne by the clypeus. The lateral margins of the clypeus are broadly rounded and the cephalic margin is bounded by a distinct clypeo-labral suture. The movable flap borne at the cephalic end of the clypeus is the labrum. The area laterad of the clypeus and labrum and cephalad of each

mandibularia is a mandible and belongs to the movable parts of the head.

Draw the dorsal aspect of the head and name all the parts.

The foramen is the large more or less quadrangular opening situated in the caudal part of the ventral aspect of the head. The postgenae bound each side of the cephalic half of the foramen. Each postgena is bounded on its lateral margin by an occipital suture, which is located on the dorsal side of the fine ridge situated about midway between a compound eye and the foramen. There is no suture limiting the caudal extent of the postgenae. Their mesal margins are united by a transverse cuticular bar, the corpotentorium, which is a part of the endoskeleton and, therefore, not exposed externally. The opening on the caudal side of the corpotentorium is the alaforamen and the one on the cephalic side is the neuraforamen. The mesal margin of the cephalic half of each postgena is hollowed out, making a cavity between them, a maxacava, for holding the mouth-parts. The cephalic end bears a distinct postcoila. There is a prominent crassa extends caudad from the mesal side of the postcoila. The condylar projection near each lateral end of the corpotentorium on the transverse part of the cephalic margin of each postgena forms one side of a paracoila. The occiput surrounds the caudal half of the foramen. Each occipital suture becomes obsolete near an imaginary line drawn between the compound eyes and the caudal margin of the foramen. The free end of each occipital suture curves laterad. The occiput and alavertex are, therefore, fused on the caudal part of the head. The suture separating the occiput and postgena of each side is obsolete. The portion caudad of a transverse line drawn through the middle of the alaforamen is considered as the occiput. There is a narrow plate along each lateral margin of the foramen to which the membrane of the cervacoria is attached. Each of these plates is a maxillaria. Its ectal surface is folded against the ectal surface of a postgena. The exposed ental surface looks like a fold of membrane. The maxillariae are continued as a much narrower band along the caudal margin of the foramen, divided on the meson by the epicranial stem. There is a distinct notch near the caudal end of each maxillaria, an odontoidea, where a cervepisternum articulates. The cephalic third of each maxillaria is expanded and forms the projection serving as one side of the paracoila. The cervacoria is attached to the margin of the maxillariae. The opening located between the expanded cephalic end of each maxillaria

and a postgena and extending into the corpotentorium marks the point of invagination of a metatentorium.

Draw the ventral aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

MELANOPLUS DIFFERENTIALIS.—The head of the locust is robust and orcephalic and the mouth is directed ventrad and hypognathous. The short blackish or brownish oval protuberances on the dorsal and lateral aspects are the compound eyes. Their mesal margins are straight and the other margins are convex. The depressions mesad of the compound eyes where the antennae are articulated are provided with prominent whitish antacoriae. Each antacoria is limited by a thickened rim, an antennaria, which is more prominent on the dorsal half of the antacoria. The transverse thickening ventrad of each antennaria has been incorrectly homologized as a supratentoria. The lateral ocelli are located near the mesal margins of the compound eyes. The median ocellus is located on the meson between the antacoriae. The epicranial suture is only faintly indicated. It is the fine pale elevated yellowish line extending along the meson from the foramen to a transverse indentation located between the dorso-mesal angles of the compound eyes. This transverse indentation is all that remains of the arms of the Y. The depressed line extending from the meso-ventral angle of each compound eye toward the ventral margin of the head is a fronto-genal suture. The transverse suture connecting the ventral ends of the fronto-genal sutures is the fronto-clypeal suture. The broad area on the dorsal aspect extending from near the foramen to the transverse indentation marking the vestigial part of the epicranial arms is the vertex. It also includes the area caudad of each compound eye. The front is the area extending from the vestigial epicranial arms and the cephalic margin of the vertex ventrad to the fronto-clypeal suture. The front and vertex are divided into regions by ridges. The costa or keel extending through the middle of the front from the clypeo-labral suture to the dorso-mesal angles of the compound eyes is the frontal costa. It is slightly dilated or widened in the region of the lateral ocelli and also near the fronto-clypeal suture. The ridges forming its lateral margins are rounded and the surface between the ridges is concave. The frontal costa is obsolete on the vertex. The ridge or carina on each side extending from the fronto-clypeal suture dorsad to a lateral ocellus is a lateral carina. The depressed area on the frontal costa cephalad of the vestigial epicranial arms is the fastigium. Its lateral and ventral boundaries are not well marked. The depressed region on each side located between a lateral carina and the frontal

costa and extending from the clypeo-labral suture to the lateral ocellus is a lateral area. The concave area on each side located between the lateral carina and the fronto-genal suture and extending from the fronto-clypeal suture to the compound eye is the genal area. The area on each side located dorsad of a lateral ocellus and between the vestigial epicranial arms, a compound eye, and the frontal costa is sometimes bounded by sharply elevated ridges and is known as a lateral foveola. The region on each lateral aspect ventrad of a compound eye and caudad of a fronto-genal suture is a gena. The small narrow wedge-shaped piece located ventrad of each gena is a mandibularia. The transverse sclerite attached to the ventral margin of the front is the clypeus. Each dorso-lateral angle extends laterad as a small lobe to the mesal margin of a mandibularia and the ventral end of a fronto-genal suture and bears on its ventral margin a distinct precoila. There is a suture extends mesad for a short distance from near the middle of each lateral margin, the vestigial clypeal suture. The movable flap borne at the ventral end of the clypeus is the labrum. Its ventral margin is roundly emarginate and each lateral margin is convexly rounded. The brownish spot located at each lateral end of the clypeo-labral suture is a torma. The thickening on each side along the fronto-clypeal suture and the lateral carina marks the position of a pretentorina.

Draw the cephalic aspect of the head and name all the parts.

The large round opening in the dorsal part of the caudal aspect is the foramen. The transverse chitinized bridge dividing the foramen into two parts is the corpotentorium. The opening on the dorsal side of the corpotentorium is the alaforamen, on the ventral side the neuraforamen. The more or less triangular area at each lateral end of the corpotentorium is a postgena. Its lateral boundary is the suture, the occipital suture, located on the lateral aspect along the ridge marking the division between the caudal and lateral aspects. Each occipital suture originates near the caudal end of a mandibularia. The dorsal boundary of each postgena is the depressed suture, the occipito-postgenal suture, extending from the ridge near an occipital suture to a maxillaria. The mesal margin of the ventral portion of each postgena is hollowed out to provide a place for the maxillae. There is a paracoila located in each of these emarginations. The ventral end of each postgena bears a distinct postcoila. The dorsal half of the foramen is bounded by the occiput. The occipital suture of each side and the ridge associated with it are obsolete around the dorsal third of the foramen. The occiput and alavertex are fused in this region.

The rounded ridge adjacent to the dorsal part of the foramen should be considered as a part of the occiput. The occiput is divided on the meson by the epicranial stem. The opening leading into the corpotentorium where it unites with a postgena is a metatentorina. The plate forming the caudal side of each metatentorina and extending dorsad along the lateral margin of the foramen is a maxillaria. Its caudal margin is emarginate near the middle of its length, forming a coila, an odontoidea, for the articulation of a cervepisternum. The cervacoria is attached to the margin of the maxillaria.

Draw the caudal aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

LIBELLULA PULCHELLA.—The modification in the shape of the head-sclerites of this insect is due to the great development of the compound eyes. They are larger and have a greater number of facets than those of most insects. The large semiglobular areas occupying each lateral third of the head are the compound eyes. They are adjacent for a short distance on the dorso-meson. Each is bounded by a narrow band which extends around their periphery, an oculata. It is limited on the caudal aspect by a fine line-like ridge. Each oculata is prolonged as a prominent ring-like plate on the ental surface around the periphery of the compound eyes. The head is hypognathous and orcephalic. The antacoriae are minute. Each is located on the dorsal part of the cephalic aspect at the ventro-lateral angle of the mound-like area cephalad of the region where the compound eyes are adjacent on the dorso-meson. The antennariae are obsolete. The epicranial stem and the occipital sutures are obsolete. The area considered as vertex is divided into two parts by the fusion of the oculatae on the dorso-meson. The cephalic part is the triangular area located dorsad of a line drawn through the antacoriae and bounded by the compound eyes. The greater part of the surface of this area is produced into a transverse mound-like protuberance, the prevertix. The caudal part, the postvertex, is located on the dorsal aspect between the compound eyes and extends to the rounded ridge marking the division between the dorsal and caudal aspects. Each lateral ocellus is located on the cephalo-lateral portion of the cephalic part of the vertex dorsad of an antacoria. The median ocellus is much larger than the lateral ocelli and is located on the ventral part of the mound-like area midway between the antacoriae. The whitish area situated mesad of each antacoria marks the point of invagination of a prominent parademe. The area located ventrad of the prevertix and the antacoriae and between the compound eyes is the front. Its

surface is concave adjacent to the median ocellus. The dorsal and lateral boundaries of the front are the epicranial arms, which are fine furrows concealed by the swollen marginal portions of the front. The vertex is continued on each side as a narrow area, a linavertex, between the front and oculata and is continuous with a gena. The transverse line located some distance ventrad of the antacoriae is the fronto-clypeal suture. The large transverse area ventrad of the fronto-clypeal suture is the postclypeus. The mesal two-thirds of the ventral margin is deeply emarginate. The much smaller transverse area filling the emargination of the postclypeus is the preclypeus. The clypeal suture, while not distinct, yet can be readily traced. Each lateral portion of the postclypeus is infolded and bears on its dorso-mesal angle a precoila on a black spot. The semicircular flap at the ventral end of the preclypeus is the labrum. It is slightly wider than the preclypeus. The area adjacent to the mesal margin of each compound eye, a linavertex, and continuous with the narrow extension of the vertex is a gena. The narrow sclerite located along the mesal margin of each gena is a mandibularia.

Draw the cephalic aspect of the head and name all the parts.

The small quadrangular opening in the center of the caudal aspect is the foramen. The cervacoria is attached to its margin. The short transverse bar dividing the foramen is the corpotentorium. The opening on the dorsal side of the corpotentorium is the alaforamen, on the ventral side, the neuraforamen. The depression at each lateral end of a corpotentorium is a metatentorina. The caudal aspect of the corpotentorium contains two adjacent socket-like acetabula. A large parademe from the cephalic end of each cervepimeron articulates firmly in each acetabulum. This articulation permits of the great rotation of the head characteristic of these insects. The small spine-like projection on the side of the foramen just dorsad of each lateral end of the corpotentorium is an odontoidea. This serves as a point of articulation for a small cervepisternum. The portion of the head adjacent to the foramen dorsad of a line drawn through the odontoideae is regarded as the occiput and ventrad of this line as the postgenae. The occipital suture is obsolete and the occiput and postgenae are continuous with the alavertex. The great size of the compound eyes has resulted in a corresponding increase in the size of the caudal aspect. There is a suboval area on the meson of the dorsal part of the caudal aspect. The lines limiting this area mark the place of attachment of the oculatae to the head-capsule. The corpotentorium serves as a bridge to unite the postgenae. The caudal aspect adjacent to the

foramen is depressed. The depressed portion is flat and limited by a distinct carina. There is a carina extends dorso-laterad from near each metatentorina across the flat area to the carina bounding the flat area and for some distance beyond this carina. The ental surface of the carina is produced as a parademe. Each postgena extends ventrad to a mandibularia from which it is separated by a distinct oblique depressed suture. The extreme ventral end of each postgena bears a postcoila. A prominent crassa extends dorsad from near the mesal margin of each postcoila and ends at a suboval thickening. This thickening extends dorso-laterad and serves as a buffer for a cervepimeron. The crassa as well as the carina forming the lateral boundary of the flat area of the foramen terminates at the buffer. The ventral margin of each postgena ventrad of the buffer is hollowed out to make room for the maxillae. The margin of this hollow bears a prominent paracoila.

Draw the caudal aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

Harpalus Caliginosus.—The head consists of several sclerites firmly and immovably joined together, forming a strongly chitinized box or capsule. It is prognathous and cocephalic. The sutures and furrows are fine and shallow and are frequently obscured by grease unless the head is thoroughly cleaned. The small, blackish or grayish, globular swellings situated on each lateral aspect near the mouth are the compound eyes. The ocelli are wanting. There is a small depression located cephalad of each compound eye which bears the antacoria to which an antenna is attached. The antennariae are completely fused with the head. The fine line that extends transversely across the head between the compound eyes and the caudal margin of the head is the occipital suture. It is obsolete for a short distance on the ventral aspect. All that portion of the head-capsule caudad of the occipital suture is the occiput. The line on the dorsal aspect connecting the two large longitudinal depressions located on an imaginary line drawn through the cephalic margin of the compound eyes is the median portion of the clypafrons. The line extends cephalo-laterad from the lateral margin of each depression and terminates in a minute notch. If a head is soaked for some time in caustic potash, it will be found that this line is not a suture, but marks the line of closure of an infolded or invaginated area. The clypafrons is, therefore, formed by the fusion of the margins of two surfaces, the cephalic surface a part of the front and the caudal a part of the postclypeus. The large longitudinal depressions connected with the clypafrons are the pretentorinae, located in the epicranial arms. The area on

the dorsal aspect extending from the occipital suture to the clypafrons is the vertex. It also extends onto the lateral and ventral aspects, caudad and ventrad of the compound eyes. The small area located cephalad of a compound eye and extending to the cephalic margin of the head is a gena. Each gena bears a small antacoria. The transverse area located cephalad of the clypafrons is the postclypeus. The notch at each end of the clypafrons is a precoila. Each is located in what is apparently an inflexed portion of the postclypeus, a clypealia. The lateral margins of the postclypeus are strongly oblique so that the caudal margin is much broader than the cephalic. The cephalic margin is broadly shallowly emarginate and infolded. The narrow submembranous preclypeus is attached to the infolded portion and concealed by the cephalic projection of the postclypeus. Each cephalo-lateral angle of the postclypeus bears a distinct seta inserted in a puncture. It is known as a clypeal setigerous puncture. The movable quadrangular area attached to the cephalic margin of the preclypeus is the labrum. It is slightly emarginate at the middle of its cephalic margin. The three setae borne on each side of the cephalic margin of the labrum in large punctures are known as labral setigerous punctures. There is in addition to these large setae a fringe of small setae which are attached to the epipharynx. The large puncture located on the dorsal aspect near the caudo-mesal angle of each compound eye is a supraorbital setigerous puncture. The shaft of the seta is frequently broken off in old specimens, but the calyx is always distinct. The rounded ridge located mesad or dorsad of a compound eye and extending from near each precoila to the region of a supraorbital setigerous puncture is a frontal ridge. It is not well developed in this beetle, but in some species it is a distinct plate concealing the greater part of the proximal portion of an antenna. The area located between the frontal ridge and the compound eye and extending dorsad from the anatacoria dorsad of a compound eye is an antennal groove. This area is usually concave and the extent of its development depends upon the size of the frontal ridge.

Draw the dorsal aspect of the head and name all the parts.

The triangular opening in the caudal aspect is the foramen. There is a distinct angular indentation at each dorso-lateral angle. The sclerite on the middle of the ventral aspect is the gula. It extends from the foramen to the cephalic margin, where it is expanded into a transverse pregula, which is separated from the labium by a mentasuture. Each end of the pregula bears a prominent setigerous puncture. The sutures forming the lateral

boundary of the gula are the gular sutures. They mark the ventral extent of the alavertex and are more distinct on the caudal part of their course. The small pit on each side in the angle where the stem of the gula joins the pregula is a metatentorina. A part of a metatentorium can be identified as a thin plate extending dorsad from near the caudal end of each gular suture along the margin of the foramen to the angular indentation which it fills. The small concave depressed area located laterad of each lateral end of the pregula is a postgena. Its caudal boundary is the curving ridge which extends from each caudo-lateral angle of the pregula to the cephalic margin of the head. This ridge is the continuation of the occipital suture, its intermediate portion is obsolete. The cephalic margin of each postgena contains a deep postcoila. The artis of the mandible articulating in the postcoila is double and one part of it articulates in an acetabulum in an adjacent part of a gena. The articulation of each maxilla to the mesal end of a postgena, the paracoila, is concealed by the lateral end of the gular bar.

Draw the ventral aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

Protoparce Sexta.—The insects of this order have all parts of the head densely covered with scales. These have to be removed before any study of the sclerites can be made. Boil the heads of dry specimens in water. Immerse over night in three per cent caustic potash. Remove scales with fine forceps or small dull edged tool. The head is large, cubical, hypognathous, and orcephalic. The large globular structure occupying each lateral aspect is a compound eye. All its margins are convex and bounded by a distinct infolded oculata. The large depression on the dorsal part of the cephalic aspect near the mesal margin of a compound eye is an antafossa. The antacoriae are distinct. A prominent antennaria lines the periphery of each antacoria. It is large and prominent on the lateral margin, smaller on the mesal. Ocelli are wanting. They are present in some moths, two in number, frequently completely covered by the scales, and located near the margin of the compound eyes dorsad of the antacoriae. The epicranial stem is obsolete. The epicranial arms are distinct and extend transversely between the antennariae. Each then extends around the ventral side of an antennaria toward the mesal margin of a compound eye and along the compound eye to near the two projections on the ventral margin. From this point each extends mesad for a short distance. The area on the dorsal aspect belongs to the vertex. It extends caudad to the transverse area on the dorsal side of the foramen, the occiput. On the cephalic aspect the

vertex extends to the antennariae and epicranial arms and as a narrow area, a linavertex, adjacent to the mesal margin of each compound eye to the two projections on the ventral margin, a pilifer and a mandible. The broad mesal portion of the vertex is separated from the lateral portions by secondary sutures. These extend obliquely, caudo-mesad, from the dorso-lateral angle of each antennaria to the foramen. Each marks the line of fusion between a supratentorium and the ental surface of the vertex. The depression located in each secondary suture at the dorso-lateral angle of an antennaria is considered as a supratentorina. The greater part of the area on the cephalic aspect bounded by the epicranial arms is the front. There is a distinct pit at the mesal end of the ventral portion of each epicranial arm near a mandible, the lateral of the two projections of each side. Each pit is a pretentorina. Between the two pretentorinae the mesal part of the cephalic aspect is produced snout-like. There is a faint furrow extends across the middle of the cephalic aspect of the snout between the pretentorinae. This furrow marks the position of the fronto-clypeal suture. The portion of the snout-like projection ventrad of the fronto-clypeal suture is the clypeus. The horizontal ventral surface of the snout also belongs to the clypeus. The clypeo-labral suture extends between the pretentorinae along the caudal margin of the horizontal ventral surface. The lateral ends of the clypeus are involved in the formation of the pit-like pretentorinae. The precoila and postcoila are wanting. The narrow transverse area ventrad of the clypeo-labral suture is the labrum. Each lateral end of the labrum is produced into a long spatulate lobe, three or four times as long as the transverse area. The spatulate lobes, the mesal of the two projections of each side, are known as the pilifers. They have been incorrectly described as the mandibles. The angular projection laterad of each pilifer and fused at its proximal end with the head-capsule is a mandible. There projects from the ventral margin of the transverse part of the labrum a delicate whitish triangular membrane. This is a part of the propharynx. The position of the mandibles precludes considering the area ventrad of each compound eye as a gena.

Draw the cephalo-dorsal aspect of the head and name all the parts.

The large opening in the caudal aspect, divided into two parts by a median transverse bar is the foramen. The median bar is the corpotentorium. The dorsal part of the foramen is the alaforamen and the ventral the neuraforamen. The transverse area forming the dorsal boundary of the foramen is the occiput. It is situated between the caudal ends of the secondary sutures crossing the ver-

tex. The mesal half is oval in outline and each lateral fourth is a narrow band, varying somewhat in width in different individuals. The area on the caudal aspect ventrad of the occiput between the foramen and each compound eye is considered as a postgena. The occipital suture is obsolete and the exact limits of the alavertex and postgenae can not be determined. Each postgena is prolonged onto the ventral aspect as a narrow area along the margin of a compound eye to the region of a mandible where it fuses with a linavertex. The swelling on the dorsal side and near each lateral end of the corpotentorium is an odontoidea. The socket-like depression in each odontoidea is where a large cervepisternum articulates. The metatentorinae are located near each lateral end of the corpotentorium. The transverse bar forming the ventral boundary of the neuraforamen is a sclerite of the labium, the stipulae. It has been incorrectly described as a gula. The cervacoria is attached to the fine ridge bounding the foramen. There is an angular indentation in the ridge adjacent to each odontoidea. The flaring sides of the alaforamen consequently belong to the metatentoria. Each secondary suture extends from an antennaria across the vertex, passes along the lateral end of the occiput, and terminates at the foramen near an odontoidea. The region on the ventral aspect of the head between the labrum and the stipulae and the two postgenae belongs to the labium and the maxillae.

Draw the caudal aspect of the head and name all the parts.

Draw the sinistral aspect of the head and name all the parts.

Apis Mellifera.—The sutures and depressions of the head are concealed by a dense covering of setae. These should be removed by carefully scraping the surface with a small sharp tool. The head is hypognathous and orcephalic. The setae covering the head and body are characteristic in form. The function of their lateral pectinations is to collect the grains of pollen in the flowers visited by the bees.

Draw a single seta showing the calyx, the central shaft, and the pectinations.

The oval lighter colored area occupying the greater part of each lateral portion of the head is a compound eye. The mesal margin is concave and the other margins convex. The surface is densely setiferous. The setae are inserted between the ommatidia and are simple. The white membrane in each of the round subadjacent openings slightly ventrad of the middle of the cephalic aspect is an antacoria. It is attached to a ring-like antennaria. The ventral side of each antennaria has a sector-like projection, an antacoila. The three small tubercles placed on the dorsal aspect

near the ridge marking the division between the dorsal and caudal aspects are the ocelli. The median ocellus is subequal to the lateral ocelli in size. The epicranial stem and epicranial arms are obsolete. The inverted U-shaped suture situated just ventrad of the antacoriae is the fronto-clypeal suture. The enclosed shield-shaped area is the clypeus. The shape of the suture is due to the increase in size and change in position of the clypeus. The prominent emargination in each lateral angle of the clypeus is a precoila. Each lateral angle is supported by a thickening. The transverse area attached to the ventral margin of the clypeus is the labrum. The slight thickening in each lateral end of the clypeolabral suture is a torma. The distinct slit in the dorsal part of each lateral portion of the fronto-clypeal suture is a pretentorina. The large area occupying the dorsal aspect and the cephalic aspect, except the clypeus and labrum, belongs to the vertex and front. The front comprises a small part of the area adjacent to the antacoriae, how much, it is impossible to determine because of the obsolesence of the epicranial arms. The vertex extends onto the lateral and caudal aspects. Identify all the orbits.

Draw the cephalic aspect of the head and name all the parts.

The opening in the caudal aspect is the foramen. The head about the foramen is concave. The angular projection on each side of the foramen is an odontoidea, against which a cervepisternum articulates. The slender bowed transverse bar extending across the foramen dorsad of the odontoideae is the corpotentorium, dividing the foramen into an alaforamen and a neuraforamen. The distinct depression near each ventro-lateral angle of the foramen is a metatentorina. The cervacoria is attached to the edge of the foramen. The area on the caudal aspect dorsad of an imaginary line drawn through the odontoideae is considered as the occiput. The occipital suture is obsolete. The ridge marking the boundary between the lateral and caudal aspects is broadly rounded and the occiput and linavertex are indistinguishable. The area ventrad of the occiput and of an imaginary line drawn through the odontoideae is considered as the postgenae. There are no sutures or ridges separating the postgenae, alavertex, and occiput. The postgenae extend mesad, fuse, and form a transverse plate ventrad of the foramen, a genaponta. Each postgena is also prolonged for some distance ventrad of the genaponta. The ventral end of each of these prolongations bears a distinct postcoila. There is a crassa extends dorsad from the mesal margin of each postcoila as the edge of a sharp ridge to the genaponta. The postgenae are produced cephalad along the crassa at right angles to the caudal surface of

the genaponta and postgenae. The middle of the cephalic margin of each side bears a long paracoila. The cavity bounded by the genaponta and the ventral extension of the postgenae, in which the mouth-parts are retracted, is the maxacava.

Draw the caudal aspect of the head and name all the parts.

Draw the sinistral aspect of the head and name all the parts.

Vespa Maculata.—Practically all the sutures of the head-capsule are obsolete. The head is hypognathous and orcephalic. The blackish area located on each lateral aspect is a compound eye. They are longer than broad and there is a deep emargination on the mesal margin. The other margins are convex. The three small pearly swellings arranged in the form of a small triangle and situated on the dorsal aspect between the compound eyes are the ocelli. Identify the four orbits. The two subadjacent depressions on the middle of the cephalic aspect are where the antennae are articulated, the antacavae. The antennariae are small and line the depressions. Each has a prominent sector-like projection, an antacoila, on its ventral margin. The antacoriae are small and inconspicuous. The epicranial stem and the epicranial arms are obsolete. The inverted U-shaped suture situated ventrad of the antafossae is the fronto-clypeal suture. The mesal part is subobsolete. The area enclosed by the fronto-clypeal suture is the clypeus. The pit on each side of the dorsal part of the fronto-clypeal suture is a pretentorina. The globular condylar protuberance at each ventro-lateral angle of the ventral margin of the clypeus is a mandocondyle. The precoila is located in the minute notch adjacent to the mesal margin of each mandocondyle. The clypeus is infolded at the ventral end onto the caudal aspect. The brownish tongue-shaped structure attached to the margin of the infolded area of the clypeus is the labrum. It can be extruded for almost its entire length beyond the ventral margin of the clypeus. The surface of the labrum is densely setiferous. The front, through the obsolescence of the epicranial suture can not be identified or distinguished from the vertex. It probably occupies a small area about the antennariae. The remainder of the dorsal and cephalic aspects belong to the vertex. It also extends onto the lateral and caudal aspects. The portion of the vertex between a compound eye and the ventral margin of the head is a gena.

Draw the cephalic aspect of the head and name all the parts.

The opening in the caudal aspect of the head is the foramen. The surface about the opening is concave. There is an indistinct furrow extends ventro-laterad on each side from near the dorsal part of the foramen across the concave area. These furrows are not

occipital sutures. The cuticle surrounding the foramen is lighter colored and thinner than the adjacent parts. It forms a flaring collar-like area about the opening. The edge to which the cervacoria is attached is thickened. The rounded projection on the middle of each side of the foramen is an odontoidea against which a cervepisternum articulates. The transverse bar located in the region of the odontoideae is the corpotentorium. It is not a bar but an inverted U-shaped structure. The end of each side of the U is attached near a caudo-ventral angle of the foramen. The pit on each side at the ventro-lateral angle of the flaring area is a metatentorina. The area on the dorsal side of an imaginary line drawn through the middle of the odontoideae is the occiput. The ridge separating the caudal from the dorsal and lateral aspects is rounded. The occiput and alavertex are continuous. The area on the caudal aspect ventrad of the foramen belongs to the postgenae. They are produced on the meson ventrad of the metatentorinae and the foramen until they fuse and form a genaponta. The mesal suture separating the two sides is obsolete. The occipital suture is obsolete. The alavertex, occiput, and postgenae form a single undivided area. Each postgena is produced for a considerable distance ventrad of the genaponta. The ventral end of each produced portion bears a prominent postcoila. There is a crassa extends from the mesal side of each postcoila as a carina along the mesal margin of the postgenae and genaponta. The postgenae are continuous from the crassa as a vertical plate at right angles to their caudal surface. The prominent condylar projection on the margin of the vertical plate of each side near the genaponta is a paracoila. The cavity in which the maxillae and labium are folded and which is located between the produced ventral parts of the postgenae is a maxacava. The vertical plate of the postgenae and genaponta bound the maxacava.

Draw the caudal aspect of the head and name all the parts.

Draw the sinistral aspect of the head and name all the parts.

Tabanus Sulcifrons.—The head is shaped like a convex-concave lens so that each lateral aspect is limited to a line. The setae on the cephalic and caudal aspects should be removed with a fine sable brush. The head is hypognathous and orcephalic. The greater part of the cephalic aspect is covered by the convex finely granular compound eyes. The dorsal half of their mesal margin is straight and vertical. The other margins are convex and conform to the general contour of the head. The line surrounding the periphery of each compound eye is an oculata. It is a distinct parademe on the ental surface. The ocelli are wanting. The com-

pound eyes, when they are contiguous or nearly so on the cephalic aspect, are said to be holoptic. This is a condition found only in males. When the mesal margins are not approximated, but are straight or uniformly convex, the compound eyes are then said to be dichoptic. This is a condition found in all females and many males. Identify the orbits. The two circular areas of membrane to which the antennae are attached are the antacoriae. They are located just ventrad of the parallel mesal margins of the compound eyes. The antennariae can not be identified. The epicranial stem is wanting unless the very faint line extending along the meson from near the dorsal margin of the head ventrad between the antacoriae, is so considered. The epicranial arms are represented by the faint line bounding the shield-shaped area ventrad of the antacoriae. The suture is distinct near the antacoriae and each ventral end is represented by a faint furrow. The area between the compound eyes and dorsad of the epicranial arms is the vertex. It extends ventrad on each side between an epicranial arm and a compound eye to the ventral margin. The portion dorsad of the antacoriae is the front of dipterists. The transverse line dorsad of the antacoriae connecting the ventral part of the compound eyes is formed by a plate on the ental surface developed from the oculatae. The region on the ventral aspect mesad of the ventral margin of each compound eye is a gena. This area is also known as the cheek. The dorsal part of the shield-shaped area enclosed by the epicranial arms is the front. The slit-like depression in the dorsal portion of each epicranial arm is a pretentorina. The fine black line marking the position of the dorsal portion of an epicranial arm is where a pretentorium is attached to its ental surface. There is a mesal furrow connecting the epicranial arms and the line connecting the oculatae. The mesal furrow is formed by a lamella on its ental surface and unites with the bar connecting the oculatae. The oblique line extending from the black line-like part of each epicranial arm to an oculata is a supratentorina. The fronto-clypeal suture is obsolete in this insect. It is usually associated with the pretentorinae. An imaginary line connecting the dorsal ends of the pretentorinae would mark its probable position. The region ventrad of the above described imaginary line is the clypeus. The entire region is known as the fronto-clypeus. Each ventro-lateral portion of the clypeus extends onto the ventral aspect. Each lateral margin is bounded by a continuation of an epicranial arm. There is a pair of furrows extends dorsad from the ventral margin across the clypeus and the greater part of the front. Each is represented on the ental surface by a parademe. The presence of these

furrows causes the ventral margin to appear biemarginate. The portion laterad of each furrow on the ventral aspect is infolded and bears a precoila. The portion of the head ventrad of the antacoriae including a part of the vertex, the front, and the clypeus is known to dipterologists as the face; while the ventral portion of the clypeus is known as the epistoma. The cephalic surface of the thin yellowish sword-shaped structure projecting from the ventral margin of the clypeus is the labrum. The caudal surface of this structure is the epipharynx, a part of the propharynx. Specimens studied in alcohol show the lateral margins of the labrum and epipharynx connected by membrane. The entire structure is known as the labrum-epipharynx. The transverse line where the clypeus and labrum-epipharynx are attached is the clypeo-labral suture. The very minute swollen area at each lateral end of this suture is a torma. The tormae are continued onto the caudal surface and connected with the epipharynx.

Draw the cephalic aspect of the head and name all the parts.

The small round opening in the caudal aspect is the foramen. The surface adjacent to the foramen is polished, differently colored, and thinner. It forms a flaring area about the opening to the edge of which the cervacoria is attached. The dorsal margin of the foramen is produced as a convex triangular horizontal black projection. Along the lateral margin of the foramen at each ventral corner of the dorsal triangular projection, there is a slender projection extends into the formen until it is almost divided into two parts. Each of these projections is an odontoidea. A cervepisternum, which usually remains attached to the odontoidea when the head is separated from the thorax, articulates against each odontoidea. The occipital sutures are obsolete. The area dorsad of an imaginary line drawn through the odontoideae is considered as the occiput. There are no sutures separating the occiput and alavertex. The four-sided area on the meson adjacent to the vertex and appearing as if a continuation of it is the epicephalon. It is not a primary sclerite. The depressed line bounding the epicephalon is where the oculatae are attached to the ental surface of the occiput. The area on each side of the foramen ventrad of the occiput is a postgena. Each is continuous with a gena and the vertex. The space on the ventral side of the foramen is filled with membrane and the proximal portion of the mouth-parts. By the obsolesence of the sutures between the labium, maxillae, and postgenae, this region is transformed into a maxaponta. The large pit in the lateral margin of the polished area at each ventro-lateral angle of the foramen is a metatentorina. The metatentoria fuse to

form a corpotentorium but it is concealed unless the maxillae and labium are removed. The flaring area about the foramen adjacent to the occiput is the parocciput and the portion adjacent to each postgena is a parapostgena. The shaggy area on the ventral portion of the postgenae and genae which is produced by long setae, sometimes of sufficient length and abundance to conceal the mouthparts, is known as the beard. The entire area of the alavertex, except the epicephalon, and postgenae is known by dipterologists as the paracephalon, some writers erroneously designate the greater part of the caudal aspect of the head as the genae.

Draw the caudal aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

Tibicina Septendecim.—The head is triangular and the exposed part consists of two oblique surfaces separated by a narrow cephalic aspect. The head is oblique, hypognathous, and orcephalic; the mouth is directed ventro-caudad but the head is described as if the mouth were directed ventrad. The setae on the ectal surface should be removed. The brownish granular globular structure located on each dorso-lateral protuberance is a compound eye. The narrow band surrounding the periphery of each compound eye is an oculata. The three semiglobular pearly areas located on the dorsal part of the cephalic aspect between the compound eyes are the ocelli. They are arranged in the form of a triangle and each ocellus is placed on a slight protuberance. There is a Y-shaped epicranial suture present in the nymph but the epicranial arms terminate near the antacoriae. In the adult the epicranial stem is the distinct furrow on the dorso-meson which terminates near the median ocellus. The furrow on the cephalic side of the median ocellus is not a part of the epicranial stem. The epicranial arms are obsolete. The swollen mesal area ventrad of the median ocellus is the frons, a part of the front. There is a triangular plate near each dorso-lateral angle of the frons, each of which is a frontal plate. The antacoriae and antennariae to which the antennae are attached are concealed beneath these plates. There are two distinct furrows extend ventrad from beneath each frontal plate. The mesal furrow of each side, a frontal furrow, forms the lateral boundary of the mesal transversely striated convex area, the frons. The frontal furrows are continued across the meson and form its dorsal boundary. The dorsal surface is flat and unstriated. There is a distinct infolded furrow on the meson of the frons. Each lateral furrow extends ventro-laterad from a frontal plate to near the middle of its length and then bends ventro-mesad. Each lateral furrow is a maxillary suture. The area between each frontal fur-

row and a maxillary suture is a jugum. The caudo-ventral end of each jugum is pointed and the mesal margin is deeply infolded. There is a pretentorina located in the dorsal end of each maxillary suture adjacent to the pale portion of each jugum and ventrad of a frontal plate. A mandibular seta is articulated to the lateral portion of the ental surface of each jugum near a pretentorina. This can not be identified. The ventral end of the frons is bounded by a distinct fronto-clypeal suture. The front comprises the areas designated above as the frons and juga and in addition a triangular area bounded by an imaginary line extending from near each antacoria to the cephalic end of the epicranial stem. The antacoriae and median ocellus are located on or near the front. The obsolesence of the epicranial arms makes it impossible to limit the cephalic extent of the vertex. It comprises the area on the dorsal aspect extending from the foramen to the cephalic end of the epicranial stem and a portion of the area on the cephalic aspect laterad of the maxillary suture. The vertex is divided into two parts by the epicranial stem. The protuberance bearing each compound eye is formed from the vertex. It extends onto the caudal aspect. There is a furrow extends caudad from the mesal corner of each frontal plate and thence caudo-ventrad terminating near the middle of the lateral margin of the foramen. A small portion of the vertex ventrad of each compound eye may be identified as a gena. The shield-shaped area attached to the ventral margin of the frons is the clypeus. All its margins, except the fronto-clypeal suture, are convex. The ventral third is infolded onto the dorsal aspect forming a strongly chitinized triangular area with a mesal groove. The suture along each lateral margin of the clypeus is the jugo-clypeal suture. The small slender pointed lobe projecting beyond the margin of the clypeus and attached near the ventral end of the triangular infolded dorsal area of the clypeus is the labrum-epipharynx. The cephalic surface of this area is the labrum and the caudal, the epipharynx.

Draw the cephalic aspect of the head and name all the parts.

The large opening occupying the greater part of the caudal aspect of the head is the foramen. The rounded projection on each side of the foramen on a line drawn through the ventral margin of the compound eyes is an odontoidea. They serve as points of articulation for the cervepisterna. The slender bar connecting the odontoideae is the corpotentorium. The two bars attached to the corpotentorium slightly nearer together than the distance from the odontoideae are the pretentoria. Each extends cephalo-laterad and is attached to the cephalic aspect of the head. The broad thin

plate attached to each lateral end of the corpotentorium near an odontoidea is a metatentorium. It extends ventrad along the lateral margin of the foramen. The elongate area on the caudal aspect adjacent to each maxillary suture and ventrad of each compound eye is a hemimaxilla. Its dorsal end is fused with the vertex without indication of suture. The ventral portion of the caudal surface of each hemimaxilla is concave. The mesal boundary of this concavity is a ridge which is continued ventrad as a long slender pointed projection, the maxillary process. It serves as a guide for a maxillary seta. The mesal margins of the maxillary processes are normally adjacent. The triangular area seen between them, when they are separated, is a part of the basipharynx. Identify the depression on each side of the foramen where the cervacoria is attached to the head near each metatentorium. There is a furrow extends dorso-laterad on each side between this line of attachment and the proximal portion of a hemimaxilla. The ventral portion is distinct and marks the position of a metatentorina. The occipital sutures are obsolete. The portion of the caudal aspect dorsad of a line drawn through the odontoideae is considered as the occiput. The portion ventrad of the occiput on each side is a postgena. The cervacoria is attached to the margin of the odontoideae and the infolded edge of the foramen dorsad of the odontoideae.

Draw the caudal aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

Benacus Griseus.—The axis of the head and body in this hemipteron forms a continuous straight line. The head is prognathous and cocephalic. The triangular area covering the dorsal and the lateral surfaces of each large lateral projection of the head is a compound eye. The oculatae can not be identified on the ectal surface. The ocelli are wanting. The large round opening in the caudal aspect, best seen from the ventral aspect, is the foramen. There is on each side of the meson of the foramen two prominent projections or parademes, the occipitaliae. The dorsal occipitaliae are longest and the lateral broadest. They can not be considered as odontoideae since they are completely covered by the cervacoria. The cervix does not contain any sclerites. The neck-like region caudad of the projections bearing the compound eyes is ordinarily retracted within the thorax and there is no articulation between it and the thorax. The epicranial stem is obsolete. The epicranial arms are distinct. They are the fine furrows which originate on the meson adjacent to the deep furrow connecting the caudo-mesal angles of the compound eyes. Each epicranial arm curves cephalo-laterad from the meson to near the mesal margin of a compound

eye and then cephalad parallel to the mesal margin. It then extends laterad and ventrad around the cephalic margin of the compound eye. The minute crescent-shaped area located on the dorsal aspect along the margin of the foramen is the occiput. It is easily identified on specimens having the occipitaliae unbroken, between which it is located. The area on the dorsal aspect caudad of the epicranial arms is the vertex. The narrow area extending between each epicranial arm and a compound eye is also a part of the vertex, a linavertex. It extends to the occiput and on each side of the occiput to the foramen and onto the ventral aspect. This latter portion extends caudad and ventrad of each compound eye and forms the ventral surface of each lateral projection which bears a compound eye. The sutures on the ventral aspect marking the mesal extent of the alavertex are obsolete. The area on the dorsal aspect surrounded by the epicranial arms is the front. Its cephalo-lateral portions are curved prolongations. The deep transverse suture at the cephalic end of each prolongation is a maxillary suture. Each lateral prolongation of the front is a jugum. The frontal furrows are obsolete and the frons and juga form a continuous area, the front. The quadrangular lobe-like area cephalad of each jugum and maxillary suture is a hemimaxilla. The cephalic margin of the front is deeply emarginate on the meson. The emargination is filled by an oval area, the clypeus. The sutures bounding the lateral margins of the clypeus, the jugo-clypeal sutures, are distinct. The suture forming the boundary between the caudal end of the clypeus and the front, the fronto-clypeal suture, is continuous with the jugo-clypeal sutures. The cephalic end of the clypeus may be concealed by the overlapping or close appression of the mesal margins of the hemimaxillae, so that the clypeus appears to be pointed. The hemimaxillae should be pushed aside so as to expose the truncate cephalic end of the clypeus. The projection longer than the clypeus and attached to its cephalic end, is the labrum-epipharynx. The greater part of its dorsal surface is transversely corrugated. This surface is the labrum. The ventral smooth surface is the epipharynx, a part of the propharynx.

Draw the dorsal aspect of the head and name all the parts.

The membrane lining the small depression located in the vertex on the ventral aspect near the caudo-mesal angle of each compound eye is an antacoria. The antennariae can not be identified. There is a long deep pocket which extends caudad from each antacoria for over half the length of the projection bearing a compound eye. It is formed by an infolding of the ectal surface and may be known as an antatheca. The antennae are folded into the anta-

thecae almost concealing, not only the antennae but the mouths of the antathecae. The ventral aspect is formed in great part from the hemimaxillae which are fused on the meson and extend to the foramen. The sutures separating the hemimaxillae from the ala-vertex and postgenae are obsolete. The cephalic portion of each hemimaxilla is separated from the jugum by a maxillary suture. The hemimaxillae extend onto the dorsal aspect adjacent to the cephalic portion of the clypeus as already described. The gula is wanting. The tentorium is greatly reduced and the pretentorinae and metatentorinae can not be identified.

Draw the ventral aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

Euschistus Variolarius.—The head is depressed and directed cephalad. The mouth opening is on the ventral aspect and directed ventrad. The head is prognathous and cocephalic. The arrangement of the parts is similar to that found in the heads of most heteropterous insects. The small globular structure located near the middle of each lateral aspect on a slight projection is a compound eye. Each covers the dorsal, cephalic, and lateral aspects of its projection. The oculatae can not be identified. The cylindrical projection on each lateral aspect cephalad of a compound eye is an antennal tubercle. An antacoria is located at the cephalic end of each. The antennariae can not be identified. The large opening in the caudal aspect of the head is the foramen. The occipitaliae are wanting. The minute globular swelling on each side slightly caudad of a line drawn through the caudal margin of the projections bearing the compound eyes is an ocellus. All parts of the epicranial suture are obsolete in the adult. The epicranial arms are distinct in all nymphal stages but the epicranial stem is obsolete. The epicranial arms in the nymph extend laterad from the meson, forming a transverse suture near to and parallel with the foramen. Each then extends cephalo-laterad through the brownish area on the caudal part of the head to near the caudo-mesal angle of a compound eye, where it becomes obsolete. The vertex in the adult is not bound on any side by a suture. It comprises a very narrow area along the foramen on the dorsal aspect, the projections bearing the compound eyes, and the antacoriae. The occiput is fused with the vertex. The genae can not be identified. The greater part of the dorsal aspect belongs to the front. It probably comprises all of the coarsely punctured area of the dorsal aspect. The front is continuous with the vertex and can not be divided into frons and juga. The two subparallel lines extending from the cephalic end of the head to a line drawn through the com-

pound eyes are the jugo-clypeal sutures. The long area forming the lateral boundary of each of these sutures is a jugum. Systematists apply this name to the cephalic end only. The frontal furrow is obsolete and the caudal extent of each jugum is not marked. Each jugum extends on the lateral aspect of the head to the suture extending cephalad from near each antennal tubercle to the cephalic margin. This suture is the maxillary suture. The sharp ridge separating the part of each jugum on the dorsal aspect from that on the lateral aspect is a jugal ridge. These ridges are located on the front. The area enclosed between the jugo-clypeal sutures is the clypeus. The cephalic end of the clypeus is known as the tylus by systematists. The small vertical area at the cephalic end of the dorsal part of the clypeus is a part of the labrum, the postlabrum. It is not fused to the head in young nymphs.

Draw the dorsal aspect of the head and name all the parts.

The long transversely striated tongue-like structure attached to the end of the postlabrum is the labrum-epipharynx. The dorsal surface of this structure is the labrum, the prelabrum, and the ventral surface is the epipharynx, which is concave, forming a trough enclosing the mandibular and maxillary setae. The mouth is the small transverse inconspicuous opening on the ventral aspect at the proximal end of the trough of the epipharynx, through which the mandibular and maxillary setae are protruded. When the rostrum or labium is removed, there appears to be a large opening, an artifact, on the ventral aspect. This opening is the labiafossa. It is guarded on each side by a prominent plate-like ridge, a bucculа. Each extends from the proximal end of the epipharynx to a line drawn through the caudal margin of the compound eyes. The ridges serve as guides for the rostrum and are highest at the cephalic end. The area forming the greater part of the mesal portion of the ventral aspect is formed by a fusion of the hemimaxillae. They are separated on each side from a jugum by a maxillary suture.. The hemimaxillae are fused on the meson without indication of suture. They bear a short depressed longitudinal line on each side of the meson adjacent to the foramen. These lines, the maxarticulae, mark the place of attachment of the maxillary setae to the ental surface of the head-capsule. The sutures separating the hemimaxillae, postgenae, and alavertex on each lateral aspect are obsolete. The bucculae are modifications of the surface of the hemimaxillae. The gula is wanting. The small quadrangular area located between the cephalic ends of the bucculae, the mouth, and the labiafossa is the gymnoid. It is a strongly chitinized area probably formed from a part of the oscula, an area of the para-

pharynx. Its surface is bent so that the two parts stand at right angles to each other, an area on the cephalic aspect and a smaller area on the dorsal. The tentorium is reduced. The pretentorinae and metatentorinae can not be identified.

Draw the ventral aspect of the head and name all the parts.
Draw the sinistral aspect of the head and name all the parts.

2. ENDOSKELETON

The cuticular plates or props of the head, the endoskeleton, are known collectively as the tentorium. The names of these parts, their position, and points of invagination have already been described. The parts of the tentorium originate during embryonic development. The number of pairs of invaginations is two. Whether the third pair of arms, the supratentoria, arises in the same way has been questioned. The lumen of these invaginations are lined with cuticle which forms the cuticular props. The free ends of the props may fuse to form a single compact series before the close of embryonic development or during nymphal or larval life or not until just at the close of the nymphal or pupal periods. The tentorium, in common with many structures of the exoskeleton, [illegible] complete development only in the adult insect. Parts [illegible]torium unrepresented in the embryo or the developing [illegible]arva may be present in the adult.

The points on the ectal surface where the tentorium was invaginated during embryonic development can be identified in many adult insects as distinct openings. In other insects these openings are closed and the original positions of the invaginations are indicated by thickenings or depressions. All indication of the position of these openings are lost in many insects. It is claimed by some investigators that these cuticular tubes are homologous with the tubes invaginated in the thorax from which the respiratory system, spiracles and tracheae, are formed. It is more likely that the tentorium is homologous with another series of invaginations found in the thorax. They form the endoskeleton of the thorax and are similar in form and method of development to the invaginations of the respiratory system.

Gryllus Pennsylvanicus.—The head of this insect is long between the cephalic aspect and the foramen. This produces a corresponding lengthening and strengthening of the parts of the tentorium. The transverse plate uniting the two postgenae, the corpotentorium, is invaginated from the metatentorinae which are located externally at each lateral end of this plate. The metatentoria also extend dorsad from each metatentorina along the ental

surface of the head. They are attached to the margins of the foramen, reaching their greatest development near its dorso-lateral angles, where three large tendons are formed, the formatendons. Each pretentorina is located near the precoila in the fronto-clypeal suture. The attachment of each pretentorium along the ental surface of a pretentorina is a long one. The ventral part of each pretentoria adjacent to a pretentorina is a triangular plate. The dorso-mesal angle of each of these triangular parts is fused to a mesal subtriangular area, the laminitentorium. This is formed by the fusion of the mesal margins of the pretentoria. The laminitentorium is continued as a triangular area, which fuses with the dorsal margin of the corpotentorium. Each supratentorium arises from the ventro-lateral angle of the laminitentorium. It extends cephalo-laterad as a distinct plate to the ental surface of each supratentorina which is located between an ocellus and an antacoria.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Blatta Orientalis.—The greater part of the tentorium of this insect is exposed by removing the mouth-parts. The plate connecting the postgenae is the corpotentorium. There is a metatentorina located on the ectal surface at each end of t[illegible]tral aspect torium in a maxillaria. The metatentoria extend arou[illegible]ugh which of the foramen as narrow plates. The thin plate ext[illegible]len the ros ventrad from each pretentorina is a pretentorium. [illegible]ace is so twisted that the same side faces in opposite direc[illegible]s in different parts of its course. The two pretentoria are p[illegible]duced mesad until they meet and fuse, forming a subquadrang[illegible]ar plate, the laminitentorium. The line of fusion is marked by a distinct ridge. There is a circular space enclosed between the dors[illegible] pretentoria. The two slender adjacent tendinous proj[illegible] extending from near the meson of the caudal margin of this circular space are the oesotendons. The dorsal end of the laminitentorium is fused to the cephalic margin of the corpotentorium. Each lateral margin of the laminitentorium opposite the middle of the enclosed circular space is produced into a thin lighter colored triangular area. The lateral end of this area is continued dorso-laterad as a small delicate thread toward the antennaria. Each of these triangular areas and its thread-like continuation is a supratentorium. It is practically impossible to prepare a specimen showing a supratentorium attached to the ental surface of the head, the caudo-lateral margin of an antennaria.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Melanoplus Differentialis.—The head is large. The parts of the tentorium are correspondingly large and elongate. The long broad heavily chitinized plate connecting the postgenae is the corpotentorium. The large opening on the external surface leading into each end of the corpotentorium is a metatentorina. The thickened area extending from each lateral end of the corpotentorium along the ental surface of the lateral and dorsal margins of the foramen to the dorso-meson, narrower at its dorsal end, also belongs to the metatentoria. Each pretentorium extends dorsad and caudo-mesad from a pretentorina as a heavy plate toward the meson, where the pretentoria fuse and form a heavily chitinized subtriangular area, the laminitentorium. The dorsal end of the laminitentorium is fused to the dorsal margin of the corpotentorium. The large tendon on each side of the ventral surface of the cephalic margin of the laminitentorium is a lamatendon. The supratentoria are attached to the lateral margin of the cephalic surface of each pretentoria near the laminitentorium. Each extends cephalad and latero-dorsad as a thin ribbon-like plate toward an antennaria. The connection of the supratentoria with the ental surface of the head has not been identified.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Libellula Pulchella.—The head of this insect, while large, is occupied in great part by the compound eyes. The portion between the compound eyes is supported by large tentorial arms. The transverse plate connecting the postgenae is the corpotentorium. Its caudal surface bears a prominent swelling on each side of the meson. Each swelling forms an acetabulum in which a parademe from a cervepimeron articulates. The openings upon the external surface at the lateral ends of the corpotentorium are the metatentorinae. The metatentoria extend as slight thickenings around the margin of the foramen and support the minute odontoideae which project into the foramen. There is a subcylindrical blackish pillar projects cephalo-laterad for a short distance from each lateral end of the corpotentorium and then divides into two fan-shaped plates. One plate extends dorsad and the other cephalad. The fan-shaped plate extending obliquely cephalad to near a precoila, where it fuses with the infolded margin of the clypeus, is a pretentorium. A part of each pretentorium is fused with the ental surface of an oculata. The laminitentorium is wanting. Each pretentorium bears two large lamatendons on its ventral surface near the corpotentorium. The fan-shaped plate extending obliquely dorsad is a supratentorium. It fuses with the ental sur-

face of the infolded edge between the front and vertex caudad of an antacoria and with the free edge of an oculata laterad of an antacoria. The oculata of each side which extends along the caudal margin of the cephalic triangular area of the vertex should not be mistaken for a part of the supratentorium. The mesal portion of each supratentorium is produced along the infolded edge between the front and vertex into a large parademe.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Vespa Maculata.—The head is compressed and the cephalic aspect is supported by large pillars extending between it and the caudal aspect. The heavy twisted pillar extending ventro-cephalad from each metatentorina to the cephalic aspect can not be divided by any visible lines into parts and is formed by the fusion of a metatentorium and a pretentorium. The part adjacent to each metatentorina belong to a mentatentorium. Each also extends as a supporting plate around the ental surface adjacent to the foramen, larger adjacent to the metatentorina. A slender bar extends dorsad from the surface of each metatentorium adjacent to a metatentorina. This bar bends mesad near the middle of the foramen and fuses with the bar of the other side on the meson forming an inverted U. This U-shaped bar is the corpotentorium. It bears a single mesal corpotendon. The part of each pillar adjacent to a pretentorina is a pretentorium. It extends as a thin plate along the entire ental surface of the vertical part of each fronto-clypeal suture. Each of the pillars formed by the fusion of a metatentorium and a pretentorium is twisted near the middle of its length. There is a slight triangular projection located on the mesal side of the dorsal surface of each metatentorium. Extending from the apex of this triangle, there is a fine cuticular thread extends across the cavity of the head toward an antacava. The triangular projection and the thread constitute a supratentorium.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Apis Mellifera.—The head is compressed and ventrad of the middle of the foramen arise the pillars of the tentorium. Each metatentorina is located near the ventro-lateral angle of the foramen. There is a large pillar invaginated from each metatentorina. Each pillar is a metatentorium adjacent to a metatentorina. The ental surface of the head adjacent to the foramen is supported by extensions from the metatentoria which completely surround the foramen. The slender curved bar, the corpotentorium, which connects the metatentoria is located within the cavity of the head near

the odontoideae. The corpotentorium bears near the meson two fine corpotendons. On the ental surface adjacent to the ventral margin of the foramen, there is a transverse thickening. This thickening is continued ventro-cephalad along the margin of each of the plates bounding a maxacava and supports a paracoila. The thickenings are completely covered by coria. The portion of the transverse pillar adjacent to a pretentorina belongs to the pretentorium. It is twisted at a different angle than the metatentorium. The complete pillar of each side is formed by the fusion of a metatentorium and a pretentorium. There is a slight swelling on the dorsal margin of each metatentorium near the foramen. This swelling bears a slender cuticular thread. Each swelling and its thread are a supratentorium. The connection of the thread with the head has not been identified.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Tabanus Sulcifrons.—This insect shows a generalized condition of the tentorium found in only a few species of this order. The large opening near each ventro-lateral angle of the foramen is a metatentorina. The plate on the ental surface arising from each metatentorina is a metatentorium. It extends dorsad around the lateral margin of the foramen, more prominent between a metatentorina and an odontoidea. There is a slender bowed plate connecting the metatentoria. This is the corpotentorium. Each metatentorium also bears a short blunt projection. These projections are attached cephalad of the lateral ends of the corpotentorium. They have been incorrectly homologized as the corpotentorium. The distinct vertical plate, invaginated from the slit located in the ventral half of each epicranial arm, a pretentorina, extends dorsocaudad and fuses with a metatentorium. This plate is a pretentorium. The oblique horizontal plate extending from each metatentorium to a supratentorina is a supratentorium. The dorsolateral end of each supratentorium adjacent to a supratentorina is fused with an oculata. The arms of the supratentorium and pretentorium of each side are connected by a thin sheet of cuticle. There is consequently a continuous plate attached along the ental surface of each epicranial arm from a supratentorina to the ventral end of a pretentorina.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Protoparce Sexta.—The tentorium in this insect contains most of the primary parts. It has been greatly modified in its arrangement. The transverse plate extending along the ventral margin of

the odontoideae, between the metatentorinae, and dividing the foramen is the corpotentorium. It bears near the meson a pair of minute corpotendons. The metatentoria extend as thin broad flaring plates from the corpotentorium around the dorsal portion of the foramen. They also extend ventrad from each metatentorina along the ental surface of the head to near the stipulae. They likewise extend for some distance along the ental surface of the thickened ridges, parts of the postgenae, extending cephalad from each lateral end of the stipulae. The large bar extending cephalad from each end of the corpotentorium to a pretentorina is a pretentorium. The cephalic half of each pretentorium bears three longitudinal lamellar expansions. The prominent cuticular projection adjacent to the mesal margin of the cephalic end of each pretentorium is a mandibular tendon. The supratentorium consists of two parts in generalized lepidopterous insects. One part extends as a plate from a pretentorium to a supratentorina located near an antennaria. This part is wanting in this species. The other part extends as a plate along the ental surface of the dorsal aspect from a supratentorina, near an oculata, to the foramen. This part is present. The supratentorinae are located near the dorso-mesal angle of an antennaria. The line of attachment of this part of the supratentorium forms a secondary suture on the ectal surface. It is fused with a metatentorium near an odontoidea.

Draw the ental surface of the caudal aspect of the head and name all the parts.

Tibicina Septendecim.—The head in most homopterous insects occupies a more primitive position than in the other suborders. There is a correspondingly more primitive arrangement of the parts of the tentorium. The slender curved bar connecting the mesal ends of the odontoideae is the corpotentorium. The slender bar, similar in diameter and appearance to the corpotentorium, extending cephalo-laterad from each side of the meson of the corpotentorium is a pretentorium. Each originates from a pretentorina located in the membranous fold ventrad of each frontal plate. There is a metatentorina located near the cervacoria in each of the furrows separating a hemimaxilla and a postgena. Each metatentorium is a large diamond-shaped area with a median longitudinal keel. The cephalic end is fused with the lateral end of the corpotentorium. The portion laterad of the keel is connected with the metatentorina and the ental surface of the postgena and concealed for the most part by the latter. The caudal end of each metatentorium is attached to one side of the basipharynx. The keel and the portion mesad of the keel lie in the foramen. The dorsal end is

obliquely truncate. The lateral angle extends dorsad of the lateral end of the corpotentorium. The mesal angle projects into the cavity of the head and is located near the point of attachment of a pretentorium to the corpotentorium. The mesal margin of each metatentorium, except the ventral portion, is free. The mesal margin of the ventral portion is fused with the parapharynx.

Draw the caudal aspect of the head and name all the parts.

Benacus Griseus.—The cephalic position of the mouth and the change in the direction of the longitudinal axis of the head are probably responsible for the changes in the tentorium. It is considerably reduced, modified, and amalgamated with the floor of the basipharynx. The supratentoria, pretentoria, corpotentorium, and metatentorinae are wanting. The caudal two-thirds of the metatentoria are easily identified. There are three broad cuticular structures in this region of the head. The mesal structure is the basipharynx and cephalic part of the postpharynx and each lateral structure is a metatentorium. The mesal margin of each cephalic end of each metatentorium is fused with the basipharynx and is also fused with the infolded portion of the maxillary suture. Each metatentorium is a long thin broad plate which extends from the parapharynx to the foramen. It is abruptly narrowed near the middle of its length. The form of the tentorium in this insect is characteristic of the Heteroptera.

Draw the ental surface of the ventral aspect of the head and name all the parts.

Corydalus Cornutus.—The tentorium of the larva is described because the head of this stage was studied. The adult differs from the larva only in having the pillars between the metatentorinae and pretentorinae much broader and a mesal projection on each pretentorium representing the sides of an unfused laminitentorium. The deep infolded cephalic portion of each gular suture is a metatentorina. The structure attached along the ental surface of the cephalic portion of each gular suture is a metatentorium. It extends caudo-mesad as a horn-shaped projection. The caudal end of this projection is prolonged dorsad as a thread-like extension. Each metatentorium also extends cephalad along the ental surface of the head and supports a postcoila. The metatentoria are prolonged dorsad as pillars. Each is fused with and indistinguishable from the pillar invaginated from the pretentorina, a pretentorium. The corpotentorium is wanting. The slight cuticular tendon attached to the caudal surface of each pretentorium is a supratentorium. It is not attached to the head-capsule.

Draw the ental surface of the ventral aspect of the head and name all the parts.

Harpalus Caliginosus.—The form and position of the tentorium has been greatly modified through the change in position of the mouth. The metatentorinae are located on each side in the angle formed by the union of the pregula and the gular stem. A metatentorium extends dorsad from each metatentorina to near the middle of the cavity located between the dorsal and ventral surfaces of the head, here they join a short transverse bar, the laminitentorium. The line of fusion on the meson can be identified. The greater part of each metatentorium is the vertical plate which extends from each metatentorina along the ental surface of a gular suture and around the margin of the foramen to its dorso-lateral angle, marking the line of migration of a metatentorina from the foramen. The very slender transverse bar connecting the dorsal margins of the two metatentoria just caudad of the laminitentorium is the corpotentorium. The pretentorinae are marked externally as short furrows. They are located on the dorsal aspect perpendicular to the clypafrons. Each pretentorium extends ventro-mesad from a pretentorina as a cylindrical pillar and fuses with the pillar from a metatentorina. The tendon-like structure which arises from the middle of the caudal margin of each pretentorium is a supratentorium. There is a thin sheet of cuticle extends ventrad from each supratentorium along the surface of each pretentorium and metatentorium. This cuticle is connected with the corpotentorium and a portion of a metatentorium extending along a gular suture.

Draw the ental surface of the ventral aspect of the head and name all the parts.

CHAPTER III

MOVABLE PARTS OF THE HEAD

The movable parts of the head consist of two antennae, two mandibles, two maxillae, and a labium. The labium is the second maxillae of zoologists. It is a paired structure in many arthropods and in the embryos of all insects. The mesal margins fuse during embryonic development and they are transformed into an unpaired appendage. The compound eyes, while not movable in insects, are considered by some as the rudiments of movable appendages and have been included with them. The propharynx and parapharynx are not true movable appendages. They are not only movable but external in some insects, and are so closely associated with the movable parts in most insects, that it is better to consider them with the movable than with the fixed parts.

A study of the fixed parts of the head shows that those species, in which there are a large number of sutures and consequently a considerable number of sclerites, are the most generalized. Specialization is indicated by the obsolesence of sutures and the resultant fusion of adjacent sclerites. These sclerites are considered as representing the terga and sterna, and possibly pleura, of the segments of which the head is composed. There is considerable disagreement, however, as to just how many segments are present. This difference of opinion has arisen from a disagreement as to what value should be assigned to certain characters. While four segments are attributed to the head by some investigators, others hold that there are as many as nine, but the great majority believe that there are only six segments in the head of all insects.

Each body segment contains typically a pair of nerve centers or ganglia and a pair of appendages in the adult and in the embryo (Fig. 4, *aba*). The nervous system of an insect appears early in its embryological development and is marked off into a definite number of enlargements, corresponding to the ganglia of the adult, which are known as neuromeres (Fig. 4, *abn*). During embryonic development the body of the insect is spread out like a sheet on the surface of the egg and the neuromeres and appendages are just as distinct and as widely separated in the head (Fig. 4) as in the thorax and abdomen. The neuromere of a segment that has lost its appendages is frequently retained longer than the rudiments of the

appendages. The number of neuromeres may be not only of more importance in determining the number of segments than the number of appendages, but also of great value in indicating the phylogeny of the group. There may be neuromeres present to represent not only each segment of the adult but to represent segments that were present only in the progenitors of insects.

The proof as to the number of head-segments is based on evidence of two sorts, the number of pairs of movable appendages and the number of pairs of ganglia or neuromeres present in the heads of developing and adult insects. It is assumed that in the primitive arthropod each segment bore a pair of appendages and contained a ganglion from which nerves arose for enervating the appendages.

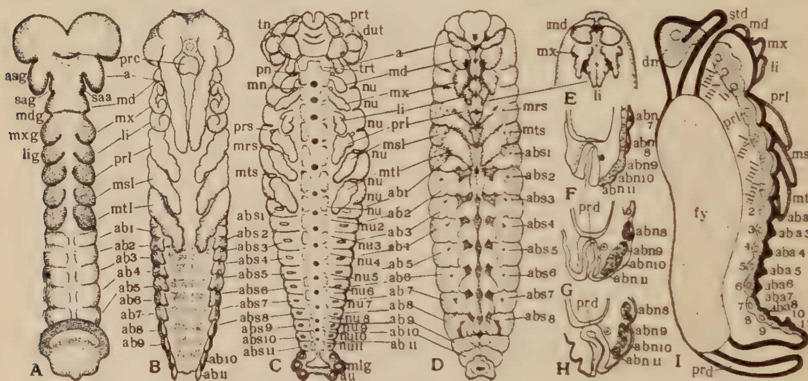

Fig. 4.—Embryos of insects. A. *Blatella germanica* (after Wheeler, modified); B, *Xiphidium ensiferum* (after Wheeler, modified); C, *Lepinotarsa decimlineata* (after Wheeler); D-E, *Hydrophilous piceus* (after Heider); F-H, *Apis mellifera* (after Nelson); and I, *Hylotoma berberidis* (after Graber). *a*, antenna; *ab 1-11*, abdominal segments; *aba 1-11*, abdominal appendages; *abn 7-11*, abdominal neuromers; *abs 1-11*, abdominal spiracles; *asg*, antennal segment; *dn*, dorsal ganglion; *dut*, deutocerebrum; *li*, labium; *lig*, labial segment; *md*, mandible; *mdg*, mandibular segment; *mrs*, mesospiracle; *msl*, mesoleg; *mtl*, metaleg; *mts*, metaspiracle; *mx*, maxilla; *mxg*, maxillary segment; *nu 1-11*, abdominal neuromeres; *pn*, pretentorina; *prc*, procephalon; *prd*, proctodaeum; *prl*, proleg; *saa*, second antenna; *sag*, second antennal segment; *std*, stomodaeum; *tn*, tentorium; *trt*, tritocerebrum.

Some of these pairs of appendages are wanting and the ganglia are fused into two large masses in adult insects, but the appendages may be present or represented by rudiments in the embryo. The origin of the nerves that enervate the appendages in the adult is also considered of value. Consequently, the evidence derived from the number of appendages and ganglia in the adult, from the number of appendages and neuromeres in the embryo, and from the origin of the nerves of the appendages in the adult, gives an exact criterion for determining the number of segments in the head of an insect.

The great majority of investigators believe that the head of an insect is composed of six segments. These are as follows: first, the ocular (Fig. 4, *ocg*) or protocerebral segment, of which the compound eyes are the appendages; second, the antennal (Fig. 4, *asg*) or deutocerebral segment, which bears the antennae; third, the second antennal or tritocerebral segment (Fig. 4, *sag*), which does not bear a pair of appendages in adult insects but is present in the embryos of generalized insects and bears the second pair of antennae in the Crustacea, which is also known as the intercalary or premandibular segment; fourth, the mandibular segment (Fig. 4, *mdg*), which bears the mandibles; fifth, the maxillary segment (Fig. 4. *mxg*), which bears the maxillae; and sixth, the labial segment (Fig. 4, *lig*), which bears the second maxillae or labium.

Those who believe that the head consists of seven segments, hold that in certain generalized insects, there is another neuromere present between the mandibular and maxillary segments. This additional segment would be the fifth and is known as the superlingual segment and bears the superlinguae as appendages, sclerites located in the prepharynx. It is claimed that the superlingual segment is represented by a neuromere, but the opponents of this view deny this contention and hold that the superlinguae are derived from the sterna of the mandibular and maxillary segments. The belief in four head-segments is based upon the number of movable appendages in the head of the adult and that in nine segments on the musculature of the head and the development of the sympathetic nervous system.

The mouth is located on the ventral aspect of the body between the second antennal and mandibular segments according to some writers and between the ocular and antennal segments according to others. In either case the point to be noted is that the mouth is not placed at the cephalic end of the body. The term mouth as here used is restricted to the irregular slit or opening, the orifice through which the food enters. The segments of the head are not typical in form in the adult. This is undoubtedly due to the great modification that has been necessary to permit of the present position of the mouth and the massing of the mouth-parts about it.

Where the food is a liquid, the mouth-parts are modified, at least some part of them or their associated structures, to form a tube through which the liquid is drawn. Since the tube is formed in a different way and usually from a different part in each group of sucking insects, the course of the food to the pharynx is very varied. This course has been variously named as the suction canal, sucking tube, food channel, food canal. This is the cibivia.

The mouth-parts are greatly modified in sucking insects. The tubular parts, those forming the cibivia and its supporting parts, have been variously designated as the rostrum or proboscis, always with the idea that they contained the cibivia. The location of the cibivia is not the same in any two of the orders with sucking mouth-parts. In order that there may be uniformity in the nomenclature, the following terminology has been used. The cibivia is formed by the mouth-cone or oraconaris, labrum and labium, in the Physopoda; by the mandibles and maxillae in the Hemiptera and is known as the rostralis, the term rostrum being restricted to the labium of this order; by the retracted tube in the Anoplura, the tubularis; by the labrum-epipharynx and hypopharynx in the Diptera, the pharyngaris, the term proboscis being restricted to the labium of this order; by the closely appressed galeae in the Lepidoptera, the galearis; by the alaglossa in the Hymenoptera, the labiaris; and by the mandibles in the Siphonaptera, the mandibularis.

1. COMPOUND EYES

The compound eyes are considered by insect embryologists as the appendages of the first or protocerebral segment. They may be round or oval and occupy only a small part of the dorsal or lateral surfaces of the head; they may be elongate oval and occupy the greater part of each lateral aspect; or they may be twice as long as wide, oval in outline or globular, and occupy a considerable part or most of the surface of the head. No matter what their shape, they are always sessile and never movable in insects, but in a few cases the portion of the head bearing the compound eyes is produced into long lateral prolongations or projections, which bear the compound eyes upon one side or at the end. They are then said to be stalked or pedunculate.

The cuticular surface of a compound eye is similar and continuous with the cuticular surface of the head. It is subdivided into a large number of adjacent areas which are hexagonal in outline. Each hexagonal area is an independent eye and shows the size and shape of the exposed part of each of the numerous closely associated eyes of which a compound eye is composed. Each of these independent eyes consists of several closely compacted but distinct elements which are located entad of the cuticle. To distinguish them from the ocelli, the true simple eyes, the subdivisions of a compound eye, are known as ommatidia. The cuticular hexagonal ectal surface of an ommatidium is known as a facet, also as a corneal lens, cornea, or ommatidium. The ectal surface of a com-

pound eye is generally uniformly convex. The facets may be flat, when the compound eyes are said to be smooth; or they may be slightly or strongly convex, when they are said to be granular. The variation in the granular appearance is due not only to the convexity of the facets but also to their size.

When each facet is convex, it is usually bounded by a flat hexagonal area, which marks the general position of the suture bounding the facet. This suture is commonly obsolete, but its position can be identified on mounted preparations by the difference in the color of the parts. The flat hexagonal area may bear setae, then the compound eye is said to be setiferous. The facets of a compound eye are usually all of the same size, but they may be very different in size, this is particularly true when each compound eye is subdivided into two parts.

COMPOUND EYES.—The compound eyes of insects vary greatly in size and number of facets. They are small globular swellings in some insects and almost completely cover the ectal surface of the head in others. There are numerous intergrades in size between these two extremes. In the Crustacea the compound eyes are frequently borne at the end of short appendages. Study the following: (1) Astacus, a cray-fish, dorsal aspect; (2) Camponotus, a worker ant, dorsal aspect; (3) Harpalus, a ground beetle, dorsal aspect; (4) Bremus, a bumble-bee, cephalic aspect; (5) Musca, the House-fly, cephalic aspect; (6) Libellula, a dragon-fly, cephalic aspect.

Draw the outline of the heads of the above, all to the same size, omitting antennae and mouth-parts, to show the comparative size and shape of the compound eyes.

ERISTALIS.—There is a variation in the size and the shape of the compound eyes not only between insects of different genera, but there may be a striking difference between the compound eyes of the two sexes of the same species. The eyes of the male are in such cases usually much larger than those of the female.

Draw the outline of the head of a male and of a female to the same size, to show the comparative size and shape of the compound eyes.

COLEOPTERA.—The mesal margin of each compound eye may be deeply emarginate or hollowed out. This emargination may proceed so far that each compound eye is divided into two distinct parts. The insect appears to have four instead of two compound eyes. With the continued deepening of the emargination, the oculata of the two sides is brought closer and closer together. When the separation into two parts is completed, the oculata of the two sides is adjacent and fused and forms a line-like suture connecting

the two groups of facets. This suture is known as the exoculata. Study the following: (1) Prionus; (2) Monochamus; (3) Tetraopes; (4) Dineutes.

Draw the lateral aspect of the head of the above, all to the same size, omitting antennae and mouth-parts, and label the parts.

Libellula Pulchella.—The facets are of two sizes, those on the dorsal aspect are larger than those on the other surfaces. The surface of the facets is uniformly flat. Each facet is bounded by a distinct narrow line, due to a slight thickening on the ental surface. Two of the sides of each facet appear to be longer than the others.

Draw six facets showing their characteristic form.

Tabanus Sulcifrons.—The facets are small and their ectal surface is flat. The adjacent facets are uniform in size and shape. The suture marking the peripheral boundary of the facets is obsolete, but its position is indicated by the heavy black line which bounds them. This line is due to a black thickening on the ental surface of the cuticle.

Draw six facets showing their characteristic form.

Apis Mellifera.—The facets are minute, but regular in form and the surface is flat and each is bounded by a narrow thickened area. Two of the sides of each facet appear to be longer than the others. There are long setae which are inserted in calices situated in the thickened area bounding the facets.

Draw six facets showing their characteristic form and the setae inserted between them.

Simple Eyes.—The organs of sight in insects are of two kinds. as already defined, simple eyes and compound eyes. The simple eyes differ in that each is an independent eye. There are two kinds of simple eyes, the ocelli and the ocellae. The ocelli are located between the compound eyes or near the meson and the ocellae are located on each lateral aspect of the head where the compound eyes are ordinarily situated. The ocelli and the ocellae do not occur in the same individual at the same time. There are never more than three ocelli present, while the number of ocellae varies from one to twenty-eight, the usual number is about six. The ocellae differ in name, but not in structure so far as known, according to the systematic group in which they are found. Study heads of the following insects showing ocelli: (1) Tibicina, a cicada, cephalic aspect; (2) Polistes, a wasp, dorsal aspect; (3) Feltia, a moth, an ocellus in each dorsal angle between a compound eye and an antennaria; (4) Anasa, a bug, dorsal aspect, two ocelli. Study the lateral aspect of the heads of the following insects showing

ocellae: (5) Protoparce, sphinx larva, with six ocellarae; (6) Pteronidea, saw-fly larva, with a single ocellara; (7) Tomocerus, a spring-tail, adult, with six ocellalae on a bluish ocularum; (8) Pseudococcus, mealy-bug, adult male, with six ocellanae.

Draw the lateral, dorsal, or cephalic aspect of the head, all to the same size, of each of the above, omitting antennae and mouth-parts, and label the parts.

2. ANTENNAE

The antennae are the movable appendages of the deutocerebral or second segment of the head. They are attached to the head by the antacoria which extends between the proximal end of the antenna and the antennaria. The antacoriae are located in the front or vertex, but more frequently in the latter, and are always closely associated with the epicranial suture. The antennae are generally considered as tactile in function. They may bear auditory or olfactory organs and are sometimes accessory organs of respiration or copulation.

An antenna consists of a single stem, a combination of the protopodite and endopodite. The exopodite is wanting. The protopodite consists of two segments, the scape and pedicel. The entopodite usually consists of a large number of segments and is known as the flagellum. In generalized insects the number is usually large and variable, consisting of about ten segments in most insects and of a single segment in a few genera.

Scape.—The first or proximal segment of an antenna is the scape and always consists of a single segment. It is normally greater in diameter than the other segments, generally longer, and cylindrical in form and is also known as an antennafer. The antatendons, the cuticular threads to which the muscles that operate the antennae are attached, are affixed to the proximal end of the scape. The scape is sometimes distinctly constricted near its proximal end. The portion proximad of the constriction is swollen, globular, or cylindrical in form and is known as the bulbus. It is sometimes longer than the remainder of the scape and is always inserted in an antacava. The antacava is formed by the infolding of the coria connecting the proximal end of the bulbus with the antacoria. While the bulbus is attached to the ectal surface of the body-wall, the insertion in an antacava gives greater freedom of movement, makes possible a closer articulation with the head, and reduces the chance of their forcible removable. The proximal end of the scape is usually provided with an antartis. The end is sometimes prolonged within the head for the attachment of muscles. The opening left by the removal of an antenna is an antafossa.

Pedicel.—The second segment of an antenna is the pedicel and like the scape always consists of a single segment. It is normally less in diameter and length than the scape and is usually globular, ring-like, or cylindrical in form. In a few insects where the antenna consists of two segments, the pedicel has been fused either with the scape or the flagellum.

Flagellum.—The portion of each antenna distad of the pedicel, whether it consists of one or many segments, is known as the flagellum. It is also known as the clavola. In generalized insects the flagellum usually consists of a large number of segments. The number is frequently not constant for the two antennae of the same individual and the sutures separating the segments, particularly toward the distal end, are irregular or incomplete. This has led some writers to consider the flagellum as a single segment which has become transversely wrinkled or folded through the necessity for great flexibility and the sutures between the segments as reduced localized transverse folds. If such is the case, the suture between the scape and pedicel and the one between the pedicel and flagellum are primary sutures and the others are secondary sutures. In specialized insects the number of segments in the flagellum has not only been greatly reduced but the number of segments is generally constant in all the individuals of a species. It is frequently the same for all the species of a genus and in some cases for all the species of a family. The segments of the flagellum, particularly those of the distal half, frequently bear a few or numerous round or oval clear areas with a pit at or near the middle. Each of these areas is known as a sensorium. The sensoria are the ectal parts of sense organs. When the flagellum bears lateral projections on one or both sides, the central portion that bears the projections is known as the stem or axis.

The antennae of insects vary greatly in form. The variation is located in the flagellum and it is used by systematists in the definition of species, genera, families, and suborders. The flagellum may have all of its segments similar in form, a few or most of them different, or the segments themselves may be similar in form and the differences in appearance be due entirely to vestiture. There may be considerable difference in the form of the antennae of the two sexes, in such cases the greater modification is usually found designated by special terms. The following are the more important of these:—

Setaceous.—An antenna is setaceous when the segments of the flagellum are successively smaller and smaller toward the distal

end, so that it tapers more or less to a point. This designation should always refer to the form of the antenna and not to its vestiture. A setaceous antenna may consist of a large number of segments or of only a few. The long setaceous antenna of many segments is a primitive type, while the one with a few segments, characteristic of certain groups, has probably been derived through a modification of some of the other types.

Filiform.—An antenna is filiform when it is slender and thread-like and the segments of the flagellum are all nearly uniform in thickness and the sides of the antennae are approximately parallel.

Moniliform.—An antenna is moniliform when the flagellum is necklace-like in form and its segments are spherical or bead-like. The sides of the antennae are usually parallel.

Imbricate.—An antenna is imbricate when the segments of the flagellum are cup-shaped with the sides high and flaring, the distal end of one segment is incumbent upon the proximal end of the next.

Basiform.—An antenna is basiform when the segments of the flagellum at its proximal end are distinctly thicker than those of the distal portion.

Fusiform.—An antenna is fusiform when the segments near the middle of the flagellum are thicker than those at either end.

Aristate.—The first segment of the flagellum is sometimes greatly enlarged and the remaining segments are setiform and attached to the first segment near the middle of the lateral surface. The setiform part of the flagellum is known as the arista and the antenna is said to be aristate. The sutures between the segments of the arista, except one or two at its proximal end, are generally obsolete. The arista may be setiferous, barbate, or plumose. The seta-like projections of the arista are not always setae.

Clavate.—An antenna is clavate when the distal portion of the flagellum is gradually but distinctly thickened, so that the antenna appears club-shaped. The thickened portion, known as the club, may include one or more segments. These segments may be closely appressed and capable not only of being opened or closed by the insect or the segments may be distinctly separated and pedunculate.

Capitate.—An antenna is capitate when the distal portion of the flagellum is distinctly and suddenly thickened, forming a knob or head consisting of one or more segments. The segments of the knob, usually known as the club, may be closely appressed, fixed or movable, or connected by peduncles.

Lamellate.—An antenna is lamellate when the distal segments

of the flagellum are extended on one side into broad flat plates, which are capable or not of close apposition. Each plate is known as a lamella. It is as thick as the axis of the segment. The lamellate type is a modification of the clavate or capitate type.

Dentate.—An antenna is dentate when one side of all or several of the segments of the flagellum is shaped like a tooth whose sides are equal. When an antenna is dentate on both sides, it is said to be bidentate. A dentate or bidentate antenna may also as a whole be filiform, basiform, fusiform, clavate, or capitate.

Serrate.—An antenna is serrate when one side of all or several of the segments of the flagellum is shaped like a tooth whose sides are unequal like the teeth of a saw. When an antenna is serrate on both sides of the axis, it is said to be biserrate. A serrate or biserrate antenna may also as a whole be filiform, basiform, clavate, or capitate.

Flabellate.—An antenna is flabellate when the cuticle of all or several segments of the flagellum is produced on one side into long slender flexible processes. The processes, even if plate-like, when they frequently resemble lamellae, are always much thinner than the thickness of the axis. When the flagellum has such processes on both sides, it is biflabellate and when the processes are covered with numerous setae as setiferous or cirrate. The form of the flagellum, exclusive of the processes, may be either setaceous or filiform.

Pectinate.—An antenna is pectinate when the cuticle of all or several of the segments of the flagellum is produced on one side into stiff inflexible processes like the teeth of a comb. The processes are known as pectinae. When each segment of the flagellum has two pectinae on one side, it is said to be duapectinate; when there are three pectinae on one side, tripectinate. The segments of the flagellum may have pectinae on both sides. When there is a single pectina on each side of each segment, it is said to be bipectinate; when there are two pectinae on each side of each segment, quadripectinate, sometimes incorrectly described as bipectinate; when there are three processes on each side of each segment, sexpectinate, sometimes incorrectly described as tripectinate. Antennae are sometimes incorrectly described as pectinate or bipectinate when there are one or more projections due to groups of long setae. The form of the flagellum exclusive of the pectinae may be either filiform or setaceous.

Appendiculate.—An antenna is appendiculate when the flagellum consists of a single segment and the surface of this segment is produced into two to many comparatively long slender flexible pro-

cesses which are usually covered with numerous setae. When consisting of two projections, such an antenna is said to be furcate.

Geniculate.—An antenna is geniculate when the distal portion is joined to the proximal portion in such a way as to form an L. Such antennae are said to be elbowed or geniculate. In geniculate antennae the scape is usually nearly as long as the pedicel and flagellum combined and the angle is formed either by the manner in which the scape and pedicel are articulated or by the pedicel being bent like an L.

Irregular.—An antenna is said to be irregular when the segments vary so much in size and shape that it can not be defined in any other manner.

There are, in addition to the terms just defined, many others which refer to modifications of the vestiture or to variations in the form of certain parts. In some chalcids the proximal segments of the flagellum, usually one to three, are very short and ring-like and are known as the ring-joints or ring-segments. In those species of this family where the distal end of the flagellum is clavate, the enlarged segments are known as the club and the segments between the club and the ring-segments as the funicle. When the ring-segments are wanting and the antenna is geniculate, the segments between the club and the scape are known as the funiculus.

When the antennae are held stiff, rigid, inflexible, and usually parallel, they are said to be porrect; when the flagellum is short, rigid, and conical, it is awl-shaped or subulate, a modification of setaceous; when short and setaceous and bristle-like, setiform; when slender like a hair, capillary; when one or more segments are much larger and thicker than the others, nodose; when the flagellum terminates in a short point, mucronate; when the distal segments are curved so as to form a hook, uncinate or hooked; and when the distal segments are fused into a long rigid spine-like projection, stylate, the fused segments being known as the style.

The arrangement and size of the setae on the segments of the flagellum produce marked changes in its appearance. When the segments of the flagellum possess numerous setae on one side, it is barbate; when on all sides, plumose; when the setae are arranged in one or more whorls on all or several of the segments, verticillate; when fringed with a row of setae on one side, fimbriate; when fringed on both sides, ciliate; when arranged in a distinct group on all or several segments, fasciculate; when one or more segments bear a dense brush of setae, scopiferous; when the flagellum is short and furnished with a terminal seta, setigerous; when the terminal seta is naked, setarious; when feathered or with lateral processes,

plumate; and when the terminal seta is enlarged at the distal end, clavate.

Blatta Orientalis.—The antenna is long and setaceous. The scape and pedicel are normal in form. The flagellum is long and feeler-like. It consists of over ninety segments. The first segment is long, the second to the twenty-fifth are short and ring-like, and the following segments are successively longer and lose their ring-like form. A large number of large and small setae are present.

Draw an antenna and name all the parts.

Melanoplus Differentialis.—The antenna is long and filiform. The scape and pedicel are normal in form. The flagellum consists of less than twenty-five segments. They are flattened, subequal in length, and sparsely covered with short fine setae. The sensoria are distinct, few in number on the proximal and numerous on the distal segments.

Draw an antenna and name all the parts.

Harpalus Caliginosus.—The antenna is filiform. The proximal end of the scape is attached by a globular bulbus. The pedicel is elongate and cylindrical. The flagellum consists of nine similar subequal segments. The proximal end of the eight distal segments is modified into a globular condyle. The distal end of the scape, pedicel, and segments of the flagellum bear large setae. The distal half of the first segment of the flagellum and all of each of the other segments bear numerous small setae.

Draw an antenna and name all the parts.

Euschistus Variolarius.—The antenna is filiform. The scape is elongate and attached by a bulbus. The pedicel is much less in diameter and longer than the scape. The flagellum consists of three subequal segments. All the segments bear a few short setae, more numerous on the second and third segments of the flagellum.

Draw an antenna and name all the parts.

Staphylinus Maculosus.—The antenna is moniliform. The scape is elongate, wider at the distal end, and attached by a globular bulbus. The pedicel is elongate. The flagellum consists of nine segments. The first segment is similar to the pedicel. The second is much shorter than the first. The second to ninth segments are bead-shaped. The proximal portion of each is produced into a cylindrical peduncle. The distal segment is mucronate, pointed. All the segments bear setae. They are of two lengths on the second to ninth segments of flagellum. Sensoria are few in number.

Draw an antenna and name all the parts.

Anopheles Maculipennis.—The antennae are very different in appearance in the female and male of this species.

Female.—The antenna is setaceous and verticillate. The scape is short, broad, swollen, and subglobular. The pedicel is elongate, the longest segment at the proximal end and the flagellum consists of twelve segments. They are successively longer. Each bears a whorl of long setae at the proximal end. The distal half of the pedicel and the segments of the flagellum bear numerous short setae. Sensoria are present on pedicel and flagellum.

Draw an antenna and name all the parts.

Male.—The antenna is setaceous and plumose. The scape is the short, broad, subglobular, swollen segment. The pedicel is enlarged at the distal end, only slightly larger than the axis of the antenna. It bears a whorl of scales and long setae. The flagellum consists of thirteen segments. Segments one to eleven are similar in length but successively less in diameter. The proximal one-fourth of each is swollen and bears a whorl of long setae. It is these whorls that make the antenna plumose. The segments between the whorls are densely covered with short fine setae. The twelfth segment is elongate, the surface is covered with promiscuously arranged long and short setae. The thirteenth segment is shorter than the twelfth, the proximal end is swollen and bears a small whorl, the surface bears setae of two lengths, and the distal end is pointed.

Draw an antenna and name all the parts.

Tabanus Sulcifrons.—The antenna is basiform. The scape has the latero-distal angle produced. The surface is densely covered with black setae. Its latero-distal angle is produced into a spine-like process. The flagellum consists of five or six segments. The proximal segment is longer than all of the others together. Its proximal half is produced into a prominent shoulder bearing a group of black setae. The four distal segments are similar and subequal. The distal segment is sometimes divided into two. The suture in such cases is located near the black seta on each lateral margin. In unmounted specimens the distal segments appear ring-like. The flagellum bears numerous fine setae and small round sensoria.

Draw an antenna and name all the parts.

Hybos Triplex.—The antenna is basiform. It is also stylate and the scape is elongate and cylindrical. It bears setae of two lengths. The pedicel is globular and also bears setae of two lengths. The flagellum consists of a single segment. The proximal portion is flask-shaped. The distal two-thirds is marked by numerous

secondary rings. The slender distal portion is known as the style. The flagellum bears numerous short black setae. There are a few sensoria on the flask-shaped portion.

Draw an antenna and name all the parts.

Calliphora Viridescens.—The antenna is aristate. The scape is short. It bears a few black stiff setae on one side. The pedicel is triangular. It bears a whorl of setae around the distal margin and a group of larger setae on one side. The flagellum consists of four segments. The proximal or first segment is the large one attached to the distal end of the pedicel. Its distal end is bluntly rounded and its surface is covered with numerous minute setae and sensoria. The bristle-like structure with numerous long slender projections attached to one side of the first segment of the flagellum is the continuation of the flagellum. It is known as the arista and constitutes segments two to four of the flagellum. The second segment is ring-like, the third is cylindrical, and the fourth is the long whip-lash-like structure. When the arista bears long prolongations as in this antenna, it is said to be plumose on the proximal half. These prolongations are not setae, but spinulae.

Draw an antenna and name all the parts.

Protoparce Sexta.—The antenna is fusiform. The scape is a large globular mass. The proximal portion bears patches of short setae. One side of the distal end is produced into a hump. This bears a tuft of long scales. The pedicel is short and ring-like. The flagellum contains about eighty segments. It is barbate with scales on one side. The opposite side of each segment, except a few segments at the proximal and distal ends, bears a group of stiff setae. They are longer and more prominent on the segments of proximal half. The setae bound a transverse oval area occupying two-thirds of each segment. The oval area bears numerous small setae and a few sensoria. The middle of the cephalic margin of the setiferous side bears a short spine. The spines are more prominent on the distal segments. The setae bounding the two sides of the oval areas project beyond the surface of the segment and the segments appear duapectinate.

Draw an antenna and name all the parts.

Epargyreus Tityrus.—The antenna is fusiform and uncinate. All of the segments are more or less covered with scales. The scape is broader than long. It bears a tuft of hair-like scales on one side of the distal end. The pedicel is short and ring-like. The flagellum contains about fifty-five segments. The proximal segments are longer than broad. The distal segments are broader than long,

some more than twice as broad as long. The distal end of the antenna is recurved forming a hook. Sensoria are fairly numerous.

Draw an antenna and name all the parts.

TENEBROIDES MAURITANICUS.—The antenna is clavate. The dilation is limited to one side of the central axis. The scape is dilated on one side and attached by a bulbus. The pedicel is constricted near the distal end. The flagellum consists of nine segments. The first segment is subequal to the pedicel. The following segments are successively slightly longer and broader and the seventh to the ninth segments are very broad and form a club. The pedicel and each of the segments of the flagellum bear setae of two lengths, the short setae are located on the dilated side of the segments. Sensoria are few in number.

Draw an antenna and name all the parts.

SILPHA SURINAMENSIS.—The antenna is clavate. The scape is long with a globular bulbus. The pedicel is shorter and smaller. The flagellum consists of nine segments. The first segment is subequal in length to the pedicel. The following segments except the ninth have the distal end successively broader. The fourth to the ninth segments are pedunculate at the proximal end. The ninth segment is cordate. The first to the sixth segments bear a whorl of large setae. The following segments bear several similar setae and are densely covered with short fine setae. They also bear a few sensoria.

Draw an antenna and name all the parts.

PIERIS RAPAE.—The antenna is clavate. The segments are numerous and the club is abrupt. All the segments bear scales. The scape and pedicel are normal in form. The flagellum contains about thirty-three segments. The proximal and distal segments are much shorter than the intermediate segments. The segments of the club are closely appressed. All the segments of the flagellum bear minute setae and sensoria.

Draw an antenna and name all the parts.

NECROPHORUS AMERICANUS.—The antenna is capitate. The scape is elongate and is provided with a bulbus. The pedicel is short. The flagellum consists of nine segments. The five proximal segments are successively shorter and successively wider at the distal end. The sixth to the eighth segments are broad and disk-shaped. The ninth segment fills the cavity of the eighth. The sixth to the ninth segments form the capitate club. Each is pedunculate at the proximal end. They are joined eccentrically. The segments bear several large setae. The seventh to the ninth

segments and the distal surface of the sixth segment are densely covered with minute cone-shaped setae.

Draw an antenna and name all the parts.

Parallelostethus Attenuatus.—The antenna is serrate in the male. The scape is elongate with a globular bulbus. The pedicel is short. The flagellum consists of nine segments. The first segment is similar in form to the pedicel. The second to eighth segments are broadly dilated on one side. They are triangular in outline. The ninth segment is slightly dilated on one side and the distal portion is constricted. The segments bear numerous long setae. Sensoria are numerous.

Draw an antenna and name all the parts.

Feltia Subgothica.—The antenna is biserrate. The scape is globular. The proximal end is constricted. The surface bears short fine setae and a tuft of unnotched scales. The flagellum consists of about eighty segments. A few of the proximal and distal segments are serrate; the segments between these are biserrate. The segments at the distal end are quadrangular, articulated eccentrically. The projections of the serrated and biserrated segments bear tufts of long setae. This gives a pectinated and bipectinated appearance respectively. The segments of the flagellum bear numerous short fine setae and a few sensoria.

Draw an antenna and name all the parts.

Hydrous Triangularis.—The antenna is clavate and biserrate. It is used as an accessory organ of respiration. The scape is elongate and curved with a small bulbus and the pedicel is elongate. The flagellum consists of seven segments. The first to third segments are short and of the same width as the pedicel. The fourth segment is shaped like a vase with one side broken off. The distal surface of the oblique distal margin is fringed with long setae. The fourth segment is Y-shaped, the stem of the Y is a peduncle. One arm of the Y is free and bears a group of long setae. The distal end of the other arm is oblique. The sixth segment is subcrescent-shaped. Its peduncle is eccentric. The free end of the crescent bears a group of long setae. The seventh segment is flat, four-sided, and pedunculate. Its distal end is in line with the free projections of the fifth and sixth. The fifth to seventh segments are densely setiferous. Sensoria are numerous.

Draw an antenna and name all the parts.

Passalus Cornutus.—The antenna is lamellate. The scape is long and curved. The bulbus is large and hooked. The flagellum

consists of eight segments. The first segment is ring-like. The second to third segments are longer than broad. The fourth and fifth segments are subequal and dilated on one side. The sixth and seventh segments are subequal to the fifth. Each is strongly dilated on one side. The eighth segment is a long, broadly rounded projection. The projections of the sixth to eighth segments are the lamellae and the shape of the lamellae makes impossible the close apposition of the surfaces of adjacent segments. The segments are setiferous. The distal surface of segments six to eight bear short curved setae.

Draw an antenna and name all the parts.

LACHNOSTERNA HIRTICULA.—The antenna is lamellate. The scape is elongate with a small bulbus and the pedicel is cylindrical. The flagellum consists of seven segments. The first segment is long. The second to fourth segments are successively shorter. Each has a slight dilation on one side. The fifth to seventh segments are very short. Each is dilated on one side into a long thin flat diamond-shaped plate, a lamella. The surfaces of the adjacent lamellae are capable of close apposition. The segments bear a few long setae. Sensoria are numerous on the surface of the lamellae.

Draw an antenna and name all the parts.

HALISIDOTA CARYAE.—The antenna is bipectinate. The scape is globular with a slight constriction. The surface is densely covered with long unnotched scales. The pedicel is short, ring-like, and bears a fringing band of unnotched scales. The flagellum contains about sixty-five segments. The first segment is similar to the pedicel. The other segments of the flagellum bear on each side near the middle a single long slender pectina. The distal portion of each pectina bears a large spine-like seta. The pectinae are setiferous and the axis is covered with scales.

Draw an antenna and name all the parts.

ANISOTA RUBICUNDA.—The antenna is quadripectinate. The scape is globular and bears a tuft of unnotched scales. The pedicel is short and cylindrical. The distal margin is fringed with unnotched scales. The flagellum contains about thirty-three segments. Each of those of the proximal half bears two pectinae on each side and are located at the proximal and distal ends of the segments. The pectinae of adjacent segments are adjacent and the antenna appears bipectinate. The axis of the antenna is subfiliform. The segments of the distal half of the flagellum are broader than long. The setae are long and numerous.

Draw an antenna and name all the parts.

Callosamia Promethia.—The antenna is quadripectinate. The scape is globular, slightly constricted and the pedicel is ring-like. The surface of the scape and pedicel bears long slender notched and unnotched scales. The flagellum contains about thirty segments. Each segment bears two pectinae on each side, except the distal four or five. The pectinae are long and filamentous. They are attached nearer the middle of the axis on the distal than on the proximal segments. The pectinae are densely setiferous. The ventral and lateral surfaces of the axis are sparsely setiferous. The dorsal surface of the axis is bare on the segments of the distal half and bears two bands of setae and a tuft of scales on those of the proximal half. Each of the nine or ten distal segments bears a multidentate projection at its distal end.

Draw an antenna and name all the parts.

Dendroides Bicolor.—The antenna is flabellate. The scape is vase-shaped with a globular bulbus. The pedicel is short. The flagellum consists of nine segments. The first to eighth segments are produced on one side of the distal end into a long flexible ringed projection. The projection is over three times as long as its segment. The ninth segment is much longer than the others and the distal half is flexible and ringed. The segments and their projections are setiferous.

Draw an antenna and name all the parts.

Schizocerus Zabriskiei.—The antenna is appendiculate. It is peculiar to the male. The scape and pedicel are normal in form and setiferous. The flagellum consists of a single U-shaped segment. The arms of the U are long and usually subequal. The surface bears transverse rows of elevations bearing long setae. This gives a ringed or segmented appearance.

Draw an antenna and name all the parts.

Sphenophorus Aequalis.—The antenna is geniculate and clavate. The scape is as long as all the other segments together. It is provided with a globular bulbus. The pedicel is short and is articulated to one side of the distal end of the scape. This permits the pedicel and flagellum to be held at right angles to the scape. The flagellum contains six segments. The first to fifth segments are subequal. The sixth segment is dilated into a club. The pedicel and flagellum are nearly glabrous. The distal half of the club is densely setiferous.

Draw an antenna and name all the parts.

Perilampus Hyalinus.—The antenna is geniculate and filiform. The scape is slender, about one-half the length of all the

other segments together. The bulbus is long. The pedicel is articulated in the distal end of the scape. It is short and L-shaped or elbowed. The bend in the pedicel permits the flagellum to be held at a right angle to the scape. The flagellum consists of eleven segments. The first segment is short and cup-shaped. It is known as a ring-segment. The second to ninth segments are similar in form. The tenth segment is smaller at the distal end, the eleventh segment is conical. The segments are setiferous. The second to tenth segments bear elongate pale sensoria-like spots.

Draw an antenna and name all the parts.

Libellula Pulchella.—The antenna is setaceous or subulate and the scape is a short cylinder. The pedicel is longer than the scape. The scape and pedicel bear setae of two lengths. The flagellum consists of four glabrous segments. They are successively smaller in diameter. The fourth segment is long, slender, and pointed. The first and second segments are longitudinally sculptured.

Draw an antenna and name all the parts.

Empoasca Coccinea.—The antenna is setaceous or subulate. The scape is short. The pedicel is subequal in length to the scape. The flagellum consists of two segments. The first segment is flask-shaped. It is divided into two subsegments by an encircling ridge The second segment comprises the remainder of the flagellum. The proximal portion of the second segment is divided by a large number of encircling folds into subsegments. The proximal end of the second segment bears a single large seta.

Draw an antenna and name all the parts.

Meloe Angusticollis.—The antenna is nodose. It is peculiar to the male and is used as an accessory organ of copulation. The antenna of the female is filiform. The scape is enlarged at the distal end with a distinct bulbus. The pedicel is normal in form. The flagellum consists of nine segments. The first and second segments are elongate, enlarged at the distal end. The third segment is similar, but its articulation with the fourth segment is eccentric, the greater part of the distal end is free and abrupt. The fourth and fifth segments are broadly flattened, the ventral surface is hollowed out. The sixth to ninth segments are similar and cylindrical, the ninth segment is the longest. The segments are setiferous with setae of two lengths.

Draw an antenna and name all the parts.

Dineutes Assimilis.—The antenna is irregular. The scape is cup-shaped with a small central bulbus. One side is deeply con-

cave. The pedicel is triangular. Its distal margin is fringed with long stiff setae. The flagellum consists of six segments, is slightly clavate, and is articulated to the proximal portion of the pedicel. The first to fifth segments are short, usually closely applied to each other, and imbricate. The sixth segment is longer. The distal end of the sixth segment bears fine setae.

Draw an antenna and name all the parts.

Benacus Griseus.—This antenna is irregular. The scape is subglobular. The pedicel is a large flat segment. One side is produced into a long broadly rounded lobe, the entire segment appears subtriangular. The flagellum consists of two segments. The first segment is a flattened L-shaped lobe, which is articulated with the pedicel by one end of the L. The second segment is a much smaller L-shaped segment with the distal end of the axis prolonged. The flagellum and pedicel are setiferous.

Draw an antenna and name all the parts.

3. MANDIBLES

The mandibles are the appendages of the fourth or mandibular segment. The appendages of the third or tritocerebral segment are present as rudiments only in the embryos of a few generalized insects. In those with the biting type of mouth-parts the mandibles are situated either immediately caudad of the labrum and clypeus or ventrad of them, depending upon the direction of the mouth. They consist of an undivided piece, which represents the protopodite of other arthropods, the exopodite and endopodite are wanting in insects.

The biting type of mouth-parts, where the mandibles are fitted for cutting, crushing, holding, or digging, is of general occurrence among generalized insects and is considered as the most primitive form. The sucking type of mouth-parts, where one or more of the pairs of mouth-parts has been modified into piercing organs or a tube for conveying liquid food, has been derived from the biting type by the suppression of certain sclerites and the elongation of others. The mandibles have either been reduced to functionless rudiments or atrophied in the great majority of sucking insects. Where they have been retained and are functional, they may be normal in form or transformed into long, slender, bristle-like, or blade-like structures.

Although they differ more or less in detail, the mandibles of biting insects are quite similar in general form. They are ordinarily pyramidal with three faces, rarely four. One of the faces appears as a continuation of the lateral aspect of the head. It is generally

triangular and usually terminates acutely at the distal end and is bent mesad, combining with the other faces to form a terminal hook. The greatest variation is found in the size and form of the projections of the mesal edge, dentary margin, or cutting edge. There is ordinarily not much variation in size and form between the mandibles of the male and female of the same species. In those males, however, that fight for their mates and a few others, there is a great difference in the size of the mandibles of the two sexes. The mandibles of the male are greatly elongated, as long as the body, and the mesal margin is produced into large simple or bifurcate teeth or horn-like processes.

Some authors consider that the same sclerites are present in a mandible as are found in a maxilla or labium. There is no foundation for such a deduction. Although the mandibles of the progenitors of insects undoubtedly consisted of a number of distinct sclerites, yet in none of the generalized species of existing insects can such sclerites be identified. The areas upon which such homologies are based, with the exception of Campodea and Machilis, are present only in specialized insects and most of them have been described from the specialized families of a single order, the Coleoptera. The following areas can be identified in the mandibles of insects:—

Preartis.—The globular swelling (Fig. 5, *pre*) located on the dorsal or cephalic aspect of the proximal end of a mandible and articulating in a precoila is a preartis. It is also known as the condilo spurio, dorsal condyle, or epicondyle.

Postartis.—The swelling (Fig. 5, *ptc*) located on the caudal or ventral aspect of the proximal end of a mandible and articulating in a postcoila is a postartis. It is frequently larger than the preartis and is sometimes divided into two parts. It is also known as the condilo vero, ventral condyle, or hypocondyle.

Mandacoria.—The membrane located on the cephalic or dorsal aspect between the mandibularia or the head, where the mandibularia can not be identified, and a mandible and between the preartis and postartis, is the mandacoria. It is frequently a narrow band (Fig. 5, *mdc*) of membrane.

Maxacoria.—The membrane located between the maxilla and the margin of the head (Fig 6, *mc*) and connecting a mandible and a maxilla is the maxacoria. It is attached from the postcoila to the paracoila, to the mesal margin of a mandible, and to the lateral margin of the maxilla from near the distal end of the stipes along the lateral margin of the stipes and cardo to the paracoila. The membrane located along the mesal margin of the proximal end

of each mandible and forming the lateral aspect of the prepharynx was originally designated as the ambipharynx. This region is not only continuous with but indistinguishable from the maxacoria and is here considered as such.

Labacoria.—The membrane located between the labium and the margin of the head (Fig. 7, *lc*) and connecting the maxilla and the labium is the labacoria, also known as the basimaxillary membrane. Its lateral margin is attached to the stipes and cardo and dorsad or caudad of the paracoila to the maxillaria or postgena. The mesal margin is attached to the lateral margin of the labium from the distal end of the mentum, along the lateral margin of the mentum and submentum to the cervix with the membrane of which it is continuous. In some insects the foramen is located in the caudal part of the head and there is a corresponding shifting of the articulations of the maxillae and labium. The maxacoria and labacoria in such species have been reduced in size and may be

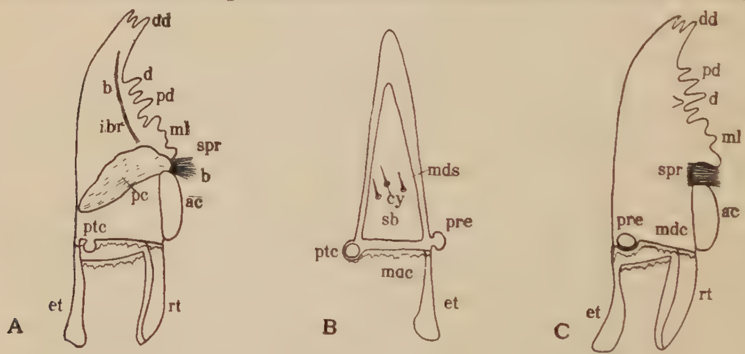

Fig. 5.—Hypothetical mandible. A, ventral aspect; B, lateral aspect; and C, dorsal aspect.

strongly chitinized so that it is impossible to separate them either from the maxillae and labium or from the head.

Rectotendon.—The tendon to which the retractor muscles are attached (Fig. 5, *rt*) is the rectotendon. It is usually very large and distinct and attached near the proximal part of the mesal margin. The proximal end is frequently large, especially in biting insects and it may form a sclerite in the coria connecting the head and mandible. This sclerite is the rectacuta.

Extensotendon.—The tendon to which the extensor muscles (Fig. 5, *et*) are attached is the extensotendon. It is generally much smaller than the rectotendon and is usually attached near the proximal part of the lateral margin, between the preartis and the postartis, generally nearer the latter. Its proximal end may be strongly

chitinized, forming a small sclerite in the mandacoria connecting the head and the mandible. This sclerite is the extensacuta.

Scrobe.—The lateral or exposed triangular surface of each mandible is sometimes concave. This concavity (Fig. 5, *sb*) is the scrobe. It is also known as the mandibular scrobe. It frequently contains one or more large setae. Their place of insertion, a calyx, is usually described as a setigerous puncture.

Mola.—The proximal portion of the mesal margin of a mandible is sometimes expanded into a large, smooth or rough, cylindrical or cubical, shoulder-like projection (Fig. 5, *ml*), a mola. The molae are evidently for grinding and are generally very different in shape on the two mandibles of the same individual. They have been incorrectly homologized with a subgalea.

Acia.—The proximal part of the mesal margin of a mandible is sometimes modified into a thin cuticular plate (Fig. 5, *ac*), the acia. When both acia and mola are present in the same mandible, the acia is the proximal of the two areas.

Dentes.—The mesal and distal margins are usually provided with angular and conical tooth-like projections (Fig. 5, *d*), the dentes. These projections are simply extensions of the surface of the mandible. In no case are they articulated although apparently so in some coleopterous species. The dentes are obsolete in many insects. The shape and position of the dentes are different in the two mandibles of the same individual so as to permit of their interlocking. The dentes located along the mesal margin and extending from the proximal end of the mola, if this structure is present, to the distal end, are the proxadentes (Fig. 5, *pd*). They may occupy the entire mesal margin or be limited to only a part of the proximal or distal portions of the mesal margin. There is only rarely a single proxadentis. The dentes located at the distal end are the distadentes (Fig. 5, *dd*). They are frequently represented by the single large distal tooth which is continuous with the lateral margin of the mandible, forming a distadentis. There is no difference in structure between the proxadentes and distadentes. When the distal margin and the adjacent part of the mesal margin are provided with dentes, it is frequently impossible to discriminate between them.

Prostheca.—The ventral or caudal aspects may be modified near the middle of the mesal margin into a lobe (Fig. 5, *pc*), the prostheca. This lobe is submembranous and is covered with setae and spinulae. It usually extends more or less obliquely across the surface of the mandible and has been incorrectly homologized with the lacinia.

Brustia.—The mandibles frequently bear bands or areas of setae or spinulae on the ventral or caudal aspect or near the mesal margin. These patches are known as brustia. Those located adjacent to the mesal margin and usually consisting of long setae are known as the suprabrustia (Fig. 5, *spr*). They are sometimes formed by dense areas of spinulae, known as pile. This is particularly true where the mesal surface of the mola is extensive. When the brustia are limited to the ventral or caudal aspect of a mandible, they are known as infrabrustia (Fig. 5. *ibr*). They are usually located some distance from the mesal margin.

Blatta Orientalis.—The dorsal aspect is convex, the ventral flat. The distal and lateral margins are continuous and regularly convex. The preartis is located near the middle of the dorsal margin. The postartis is much larger than the preartis and located on the ventral aspect near the lateral margin. The extensotendon is small and attached near the postartis. The rectotendon is large and attached near the mesal margin. The acia is the thin plate on the proximal part of the mesal margin. The mola is the flat tooth adjacent to the distal end of the acia. The dentes are not divisible into proxadentes and distadentes.

Draw the dorsal aspect of a sinistral mandible and name all the parts.
Draw the ventral aspect of a dextral mandible and name all the parts.

Melanoplus Differentialis.—The cephalic aspect is convex and merges with the small triangular lateral aspect. The caudal aspect is concave. The preartis is located at the angle between the lateral and cephalic aspects and the postartis on the caudal aspect. The rectotendon is attached near the mesal margin. The extensotendon is attached to the small oval area near the postartis. The mola is the large broad furrowed tooth near the rectotendon. The setae located along the margin of the mola form a suprabrustia. The dentes, not separable into proxadentes and distadentes, are large, black, and pointed.

Draw the cephalic aspect of a sinistral mandible and name all the parts.
Draw the caudal aspect of a dextral mandible and name all the parts.

Harpalus Caliginosus.—The dorsal aspect is flat and subtriangular, the ventral concave, and the lateral triangular and concave, forming a distinct scrobe. The preartis, located at the angle between the dorsal and lateral aspects, is concave. The postartis is located at the angle between the lateral and ventral aspects and is divided into two parts which fit over a ridge in the postcoila. The rectotendon is large and attached to the mesal margin. The extensotendon is attached to the lateral portion of the postartis. The proximal portion of the mesal margin bears a triangular supra-

brustia. The infrabrustia is the silvery line located near the mesal margin and is formed of spinulae. The mola is located at the distal end of the suprabrustia. It is more distinct on the sinistral mandible. The large distal tooth is a distadentis.

Draw the dorsal aspect of a sinistral mandible and name all the parts.
Draw the ventral aspect of a dextral mandible and name all the parts.

CALOSOMA CALIDUM.—The mandible consists of three aspects, a convex dorsal, a concave ventral, and a small concave triangular lateral aspect. The preartis, located at the angle between the dorsal and lateral aspects, is globular, protuberant, and concave at the distal end. The postartis, located at the angle between the lateral and ventral aspects, is large and divided into two parts. The large rectotendon is attached to the mesal margin. The extensotendon is attached to the lateral portion of the postartis. The proximal part of the mesal margin bears a small acia. A large suprabrustia extends along the acia for three-fourths the length of the mandible. The single large broad tooth is the mola. The proxadentes are wanting. The distadentis is represented by the large distal tooth.

Draw the dorsal aspect of a sinistral mandible and name all the parts.
Draw the ventral aspect of a dextral mandible and name all the parts.

PASSALUS CORNUTUS.—The dorsal aspect is flat, the lateral aspect is flat and setiferous, and the ventral is deeply concave. The preartis is the globular enlargement at the angle between the dorsal and lateral aspects. The postartis is the divided swelling at the angle between the ventral and lateral aspects. The extensotendon is attached to the lateral part of the postartis and the rectotendon is attached to the mesal margin. The mola is the prominent subquadrangular portion of the mesal margin, differently shaped in the two mandibles. Its dorsal and ventral surfaces are sparsely setiferous. The sinistral mandible bears a slender finger-like projection near the ventro-proximal angle of the mola. There are three proxadentes, an angular bent scraper near the mola, a bifurcate tooth distad of the scraper, and a blunt tooth on the ventral margin. The distal end bears three distadentes.

Draw the dorsal aspect of the sinistral mandible and name all the parts.
Draw the ventral aspect of the dextral mandible and name all the parts.

HYDROUS TRIANGULARIS.—The dorsal aspect is flat, the ventral concave, and the lateral triangular and concave. The preartis is the large acetabular depression located at the angle between the dorsal and lateral aspects. The postartis is located at the angle between the ventral and lateral aspects. It is divided into a globular protuberance on the ventral and a broad shoulder on the lateral

aspect. The rectotendon is attached to the mesal margin. The extensotendon is attached adjacent to the lateral part of the postartis. The mola is the large densely spinulate area forming the proximal part of the mesal margin, concave on the sinistral and convex on the dextral mandible. The densely spinulate submembranous area with two oblique folds distad of the mola is the prostheca. Each mandible bears three bifurcate proxadentes and a single bifurcate distadentis. The cuticle about the proximal ends of the proxadentes may be submembranous and the proxadentes movable. The infrabrustia extends from the prostheca to the distal proxadentis. The suprabrustia is located adjacent to the proximal proxadentis.

Draw the dorsal aspect of a sinistral mandible and name all the parts.
Draw the ventral aspect of a dextral mandible and name all the parts.

Pinotus Carolinus.—The dorsal aspect is crescentic and flat. The lateral aspect is sinuate, subtriangular, and concave and bears a longitudinal row of stout setae. The ventral aspect consists of a lateral longitudinal strongly chitinized portion and a mesal membranous portion. The acetabular artis at the dorsal angle of the proximal end of the lateral aspect is the preartis. The artis at the ventral angle of the lateral aspect is the postartis. It is divided into two parts, one part is globular. The extensotendon is small and attached near the postartis. The rectotendon is attached on the ventral aspect near the mesal margin. The transverse brownish area on the mesal margin near the rectotendon is the mola. Its mesal surface is concave in the sinistral mandible and convex in the dextral and covered by dense spinulate pile. The opaque white folded area of membrane at the distal margin of the mola is the prostheca. The proxadentes are represented by a single minute seta-like projection on the mesal membranous margin near the prostheca. There are two large distadentes. The ventral membranous area is finely longitudinally rugose and the mesal margin bears a band of long seta-like spinulae.

Draw the dorsal aspect of a sinistral mandible and name all the parts.
Draw the ventral aspect of a dextral mandible and name all the parts.

Vespa Maculata.—Each mandible consists of two aspects, a convex lateral and a concave mesal aspect. The preartis is the swollen angular area located at the proximal end of the mesal margin. There is laterad of the preartis a distinct emargination, an acetabulum, in which the mandacondyle on the ventral margin of the gena articulates. The small globular swelling located near the proximal end of the lateral margin is a postartis. The extensotendon is attached near the postartis. The rectotendon is large

and attached near the middle of the mesal aspect. It is associated with a large rectacuta. The mesal margin is angular, the distal half a cutting edge, with a distinct furrow on the ventral aspect laterad of the cutting edge. The cutting edge is not divided into proxadentes. There are three distadentes, the proximal one continuous with the cutting edge.

Draw the lateral aspect of a sinistral mandible and name all the parts.
Draw the mesal aspect of a dextral mandible and name all the parts.

Apis Mellifera.—The mandibles are spatulate, consist of two aspects, a continuous setiferous convex lateral aspect and a concave setiferous mesal aspect. The preartis is located at the proximal end of the mesal margin. The broad projection at the proximal end of the lateral margin is the postartis. There is another artis mesad of the postartis to which the extensotendon is attached. The large rectotendon is attached near the middle of the proximal end of the mesal aspect. The proxadentes and distadentes are wanting. The distal half of the mandible is modified into a spatula for molding wax and other materials. The infrabrustia is located on the mesal aspect and consists of two oblique rows of stout curved setae.

Draw the lateral aspect of the sinistral mandible and name all the parts.
Draw the mesal aspect of the dextral mandible and name all the parts.

Tabanus Sulcifrons.—The mandibles are broad yellowish sword-shaped blades without teeth. The lateral margin is nearly straight and the mesal convex. The proximal end is bifurcate. The pointed arm of the bifurcation bears a slender tendon. This arm articulates in a precoila and is considered as the preartis. The tendon is the extensotendon. The postartis is obsolete. The other arm, the mesal, is blunt. It is a secondary structure developed for the attachment of the rectotendon. The thickening extending obliquely proximad from the mesal margin to near the rectotendon regulates the position of the mandible when it is retracted.

Draw a mandible and name all the parts.

Benacus Griseus.—The mandibles of this insect are long slender bristle-like structures. The proximal half or more is enclosed in the head and attached to the ental surface of the dorsal aspect by cuticular ligaments. The proximal end rests against an occipital projection. The distal portion is enclosed in a rostrum or tube open on one side, formed from the labium. The mandibles are very similar in form to the maxillae. They have four or five recurved proxadentes near the distal end. The proximal end is tubular with a single tendon, probably the rectotendon. The two margins are dilated, forming thin marginal wings so that one aspect is convex

and the other, where the mandible is folded against a maxilla, is concave. The folding together of the mandibles and maxillae forms a cibivia through which the liquid food is drawn.

Draw a mandible and name all the parts.

Corydalus Cornutus.—The mandibles of this species show a striking sexual dimorphism. The reason or use for the great elongation of the mandibles of the male is not known.

Female.—The dorsal aspect is convex, the ventral flat, and the lateral triangular, concave on the proximal half. The acetabular artis at the proximal end of the ridge between the dorsal and lateral aspects is the preartis. The condylar swelling near the proximal end of the ridge between the lateral and ventral aspects is the postartis. The extensotendon is small and attached near a postartis. The rectotendon is large and attached to the mesal margin. The mesal margin bears three proxadentes and a distadentis, rarely two distadentes in the sinistral mandible, a minute one on the ventral aspect.

Draw the dorsal aspect of a sinistral mandible and name all the parts.
Draw the ventral aspect of a dextral mandible and name all the parts.

Male.—The mandibles are falcate cylindrical structures eight or ten times as long as their greatest width. The surface is covered with minute tubercles arranged in interrupted transverse rows. The rectotendon is attached to the mesal margin. The extensotendon is attached to the lateral margin. There is a transverse depression extending across the lateral aspect of the mandible from near the extensotendon. The condylar swelling on the ventral aspect near the extensotendon is the postartis. The acetabular artis located on the dorsal aspect is the preartis. The distal portion bears a minute proxadentis and an acute distadentis.

Draw the dorsal aspect of a sinistral mandible and name all the parts.
Draw the ventral aspect of a dextral mandible and name all the parts.

4. MAXILLAE

The pair of appendages located ventrad or caudad of the mandibles, depending upon the direction of the mouth, is the maxillae. They are the appendages of the fifth or maxillary segment. In biting insects the maxillae are organs of prehension. Certain parts in all insects, however, probably function as organs of special sense. The maxillae are attached to the maxillariae where these structures are present. They represent the fixed parts of the maxillary segment, but are usually indistinguishably fused with the occiput and postgenae, the latter of which in most cases bear the paracoilae for the articulation of the maxillae.

All three of the primary divisions of a typical arthropod appendage is present in a maxilla. The protopodite, the proximal portion, consists of two or three sclerites, a cardo of one or two segments and a stipes. The stipes bears the exopodite and the endopodite. The latter in insects is longitudinally divided into an inner lobe and an outer lobe, the lacinia and galea. The exopodite is represented by the maxillary palpus, a slender appendage of five segments or less.

The paracoilae, the articular surfaces located on the cephalic or ventral end of the maxillariae, on the postgenae, or on the sides of the maxacava, are the places of articulation of the maxillae. These surfaces vary in form and in some insects are distinct condyles. The proximal end of the maxilla is usually deeply concave. The projection on one side of this concavity articulates on the external surface of the paracoila and the other on the internal surface. There is a broad area of infolded membrane in generalized biting insects connecting the mesal margin of the cardo and stipes with the lateral margin of the submentum and mentum, parts of the labium. This membrane, the labacoria, is continuous with the membrane connecting the mesal margin of a paracoila and maxillaria with the cervix. There is also a broad area of membrane, the maxacoria, connecting the lateral margin of the cardo and stipes with the ventral part of the caudal margin of the head and extending to the postcoila. The maxacoria in generalized insects constitutes the greater part of the dorsal or cephalic aspect of the maxilla. The sclerites of the maxillae and labium, that belong to the protopodite, may become an integral part of the head and inseparable from it by chitinization of this membrane. The sclerites of the exopodite and endopodite are not connected except at their proximal ends and are freely movable about the mouth. This arrangement of the stipes and parts of the cardo and the membrane connecting them with the head and labium provides a considerable opening through which the muscles that operate the maxilla can enter for insertion on its ental surface. The cardo and stipes are wholly or in part tubular in some specialized insects and the muscles are attached to tendons inserted on the ental surface of the maxilla.

The parts of the maxillae are usually greatly elongated in sucking insects. In some the entire sucking apparatus is formed from the maxillae, in others they are only accessory parts. The maxillae may be modified into blade-like or bristle-like piercing organs or they may be rudimentary, represented by a few functionless plates. The following parts can be identified:—

Cardo.—The proximal region of the maxilla (Fig. 6, *ca*) is the

cardo. It is very variable in form. In some sucking insects it is completely fused with the head. The cardo in most insects is a single sclerite, but in some generalized species it consists of two closely associated pieces. One of these pieces is articulated to the paracoila and the other to the stipes, the sclerite distad of the cardo.

Subcardo.—The proximal sclerite of the cardo (Fig. 6, *sa*), when it is divided, is the subcardo, also known as the paracardo. It bears the artis, the parartis, which articulates with the paracoila.

Alacardo.—The distal sclerite (Fig. 6, *al*) of the cardo is the alacardo, also known as the eucardo. It is usually located along the lateral margin of the subcardo and is separated from it by a longitudinal suture. The distal end of the alacardo is articulated to the stipes.

Parartis.—The swelling located at the proximal end of the subcardo or cardo (Fig. 6, *par*) as the case may be and which

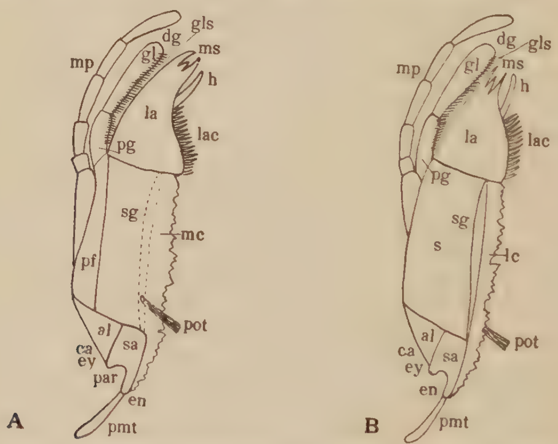

Fig. 6.—Hypothetical maxilla. A, dorsal aspect; B, ventral aspect.

articulates against the paracoila is the parartis. It is frequently concave or bifurcate, especially in generalized insects. One arm of this bifurcation articulates on the external surface of the paracoila (Fig. 6, *ey*) and is known as the exparartis. The other arm articulates on the internal surface of the paracoila (Fig. 6, *en*), bears tendons extending into the head, and is known as the entoparartis.

Stipes.—The large quadrangular or subquadrangular sclerite (Fig. 6, *s*) forming the intermediate part of a maxilla is the stipes, also known as the enstipes or basistipes. Its proximal end is fused to the alacardo or, where the subcardo and alacardo are fused, to

the cardo. The stipes bears at or near its distal end the exopodite and endopodite.

Subgalea.—The elongate sclerite (Fig. 6, *sg*) located along the mesal margin of the ventral or caudal aspect of the stipes is the subgalea, also known as the parastipes. This sclerite is not well developed in many insects and in others is fused with the stipes. It is usually distinct and strongly chitinized in coleopterous insects.

Maxatendons.—One side of the cardo and stipes is open in many insects and the muscles that operate the maxillae are attached on the ental surface of these sclerites. They are tubular, particularly the cardo, in certain specialized insects and the muscles are attached to the large tendons, the maxatendons.

Premaxatendon.—The maxatendon (Fig. 6, *pmt*) attached to or near the entoparartis is the premaxatendon. The retractor muscles are attached to this tendon.

Postmaxatendon.—The maxatendon (Fig. 6, *pot*) attached to the ental surface of the subgalea is the postmaxatendon. The extensor muscles are attached to this tendon.

Palpifer.—The small shoulder-like sclerite (Fig. 6, *pf*) attached to the disto-lateral angle of the stipes is the palpifer. It is the proximal sclerite of the exopodite and is frequently not well defined in generalized insects, but in coleopterous species is bounded on all sides by sutures. The palpifer is tubular in some sucking insects, constricted at the proximal end, and is frequently erroneously considered as the proximal or first segment of the maxillary palpus.

Maxillary Palpus.—The segmented appendage attached to each palpifer (Fig. 6, *mp*) is a maxillary palpus. It consists typically of five segments, never more than this number, but in many groups has been reduced to a smaller number. All the segments in certain groups are wanting. The distal end of the distal segment is usually membranous and bears numerous conical setae, which are organs of special sense, tactile organs.

Galea.—The appendage attached to the distal end of the stipes mesad of the palpifer and maxillary palpus is the galea (Fig. 6, *gl*). It consists typically of two segments in biting insects and is rarely reduced to a single segment by fusion of the two parts. Where the subgalea is prominent, the galea sometimes appears to be attached to it. The principal part of the sucking tube in some and the principal part of the piercing organ in other sucking insects is formed from the galeae. It is one of the most persistent parts of the maxilla and in biting insects may be enlarged at the distal end, club-shaped or spoon-shaped. The galea may also be long, slender, and thread-like. It is also known as outer, upper, or

superior lobe. The proximal segment of the galea (Fig. 6, *pg*) is the proxagalea. The distal segment (Fig. 6, *dg*) is the distagalea and is frequently much larger than the proxagalea. They are also known respectively as the basigalea and distigalea.

Lacinia.—The appendage attached to the distal end of the stipes (Fig. 6, *la*) mesad of the galea is the lacinia, also known as the inner or inferior lobe. When the subgalea is well developed, it is usually attached to its distal end. In generalized insects the lacinia is a prominent sclerite with the distal end toothed and frequently bent to form a hook. The distal hook may be wanting, or greatly reduced in diameter, so that it looks like a large seta, the digitus. In addition to the distal teeth, the mesal margin frequently bears a band of prominent setae. The lacinia is reduced to a membranous lobe or is wanting in sucking insects. It never forms an important part of the sucking apparatus and may be decadent in biting insects. The distal end of the lacinia may be divided into two distinct lobes. The lateral lobe in such cases, the one adjacent to the galea, is the lacinella and the mesal lobe is the lacinoidea. The teeth borne at the distal end of the lacinia (Fig. 6, *ms*) are the maxadentes. There are typically three teeth, but the number may be reduced to one or two. There is sometimes a peculiar tooth-like projection proximad of the maxadentes (Fig. 6, *h*), the hamadens.

Rastra.—The row of long or short setae, usually arranged like the teeth of a rake, located on or near the margin of the lacinia or galea is a rastra. The comb or dense brush of setae forming a rastra on the margin of the galea (Fig. 6, *gls*) is a galarastra and the one on the margin of the lacinia (Fig. 6, *lac*) is the lacinarastra. They are also known as the galeafimbrium and laciniafimbrium respectively.

Blatta Orientalis.—The ventral aspect is strongly chitinized, the dorsal membranous. The proximal sclerite is the subcardo. It is subquadrangular on the ventral and subtriangular on the dorsal aspect. The parartis is located on the dorsal aspect. The minute exparartis is proximal and the entoparartis is distal in position. The premaxatendon is attached near the entoparartis. The alacardo is the small convex triangular area on the ventral aspect distad of the subcardo. The sclerite articulated to the subcardo and alacardo is the stipes. The long narrow sclerite along the mesal margin of the stipes is the subgalea. The five-segmented appendage attached to the dorsal aspect of the maxilla near the lateral margin is the maxillary palpus. The first segment is short and cylindrical, sometimes appearing elbowed, the second segment is longer. The fourth segment is always enlarged at the distal end. The fifth

segment is membranous on one side. The small sclerite located on the dorsal aspect at the proximal end of the maxillary palpus is the palpifer. It appears in mounted specimens to be on the ventral aspect. The disto-mesal angle of the stipes at the distal end of the subgalea is a rounded lobe. The distal boundary of this lobe is a transverse coria. There is a short longitudinal suture extends distad from the lateral end of the coria. This suture is where the lacinia is attached to the stipes. The lacinia is beak-shaped. The curved distal end bears two teeth, the maxadentes. The mesal margin is strongly convex and bears a prominent lacinarastra. The peculiar triradiate structure situated near the distal end of the lacinarastra is the hamadens. The appendage located between the lacinia and maxillary palpus is the galea. The proxagalea is the transverse flattened cylindrical area attached to the distal end of the stipes for the greater part of its width. The suture between the stipes and proxagalea is wanting. The distal boundary is a transverse constricted fold. The distagalea is three times as long as the proxagalea. The mesal half of its ventral aspect is deeply concave, the lateral boundary of the concavity is marked by a slender brownish band. The distal end is abruptly flaring and convex and bent onto the mesal aspect. This convex area is opaque white and membranous and the proximal end is angularly emarginate, the emargination is continuous with the mesal cavity. The maxadentes are folded into the concavity of the galea. The margin of the subcardo, subgalea, and stipes on the ventral aspect is continuous with the labacoria. The membrane on the dorsal aspect attached to the subcardo, alacardo, and stipes is continuous with the maxacoria.

Draw the ventral aspect of a maxilla and name all the parts.

Melanoplus Differentialis.—The caudal aspect is strongly chitinized and the cephalic is membranous. The cardo is triangular in outline and consists of a subcardo and an alacardo. The subcardo is the small subquadrangular sclerite located along the mesal margin of the caudal aspect. Its proximal end is deeply bifurcate, one arm, the exparartis, is a bluntly pointed blackish projection and the other, the entopartis, is a long thin projection bearing a premaxatendon. The lateral boundary is a longitudinal furrow, usually blackish in color. The large triangular area along the lateral margin of the subcardo is the alacardo. The lateral portion of the alacardo is crossed by a deep oblique secondary furrow. It divides the alacardo into two parts which are often mistaken for distinct sclerites. The distal portion of the subcardo and alacardo is membranous. The quadrangular area on the caudal aspect at-

tached to the distal margin of the alacardo is the stipes. The boundary between the stipes and alacardo is a distinct transverse suture. The small area attached to the mesal margin of the stipes is the subgalea. The two are separated by a furrow. There is a similar furrow extends from near the disto-lateral angle of the alacardo to the distal end of the stipes. This furrow, at the bottom of which there is a suture, is located near the lateral margin of the caudal aspect, and forms one of the boundaries of the stipes. The sclerite on the lateral side of this furrow and adjacent to the disto-lateral angle of the alacardo is the palpifer. It extends distad to the notch on the lateral aspect. It also extends onto the cephalic aspect. The maxillary palpus, consisting of five segments, is attached on the cephalic aspect to the distal end of the palpifer. The area located on the caudal aspect distad of the palpifer is the proxagalea. Its lateral margin is deeply emarginate. The proximal half of the mesal margin of the proxagalea is separated from the stipes by the suture at the bottom of the lateral furrow. The distal half is free. The distal boundary of the proxagalea is a transverse fold on the caudal aspect and is a thickened suture on the cephalic. The palpifer and proxagalea form the lateral aspect of the maxilla. The membrane forming the cephalic aspect of the maxilla and attached to the alacardo, palpifer, and proxagalea is a part of the maxacoria. The distagalea is about three times as long as the proxagalea, strongly compressed, and spoon-shaped. The claw-shaped structure mesad of the galea is the lacinia. It is attached to the distal end of the stipes and bears three maxadentes. The coria attached to the margin of the subcardo and subgalea is the labacoria.

Draw the caudal aspect of a maxilla and name all the parts.

Draw the distal end of a maxillary palpus, greatly enlarged, showing the tactile organs.

Harpalus Caliginosus.—The ventral aspect and the dorsal aspect in part are strongly chitinized. The aspects can be identified from the insertion of the long slender seta on the proximal half of the ventral aspect. The cardo is not subdivided. The distal portion of the dorsal aspect is membranous. It is a club-shaped piece with the distal portion convex and subglobular and the proximal portion small and subcylindrical. The lines of attachment of the maxacoria and labacoria are near each other on the proximal portion. The exparartis, which is slightly emarginate, is located at the proximal end of the cardo. The entoparartis, to which a premaxatendon is attached, is a small projection located on the dorsal aspect near the exparartis. The suture at the distal end of the cardo on the ventral aspect is a narrow corea. The quadrangular area on the

lateral part of the ventral aspect attached to the cardo is the stipes. It bears the long slender seta. The stipes is folded onto the dorsal aspect as a small triangular area. The distal end of the stipes on the dorsal and ventral aspects is inclined in a different direction. The angular area on the ventral aspect at the distal end of the stipes is the palpifer. It is longer and similar in position on the dorsal aspect. The maxillary palpus is attached to the distal end of the palpifer. It consists of four segments. The sclerite located on the ventral aspect along the mesal margin of the stipes and palpifer is the subgalea. There is a prominent postmaxatendon attached to its ental surface. The distal end of the subgalea is fused with the claw-like lacinia, the suture between them is obsolete. The distal end of the lacinia is hooked and its mesal margin bears a lacinarastra of long curved setae. The distal end of the stipes is prolonged as a slender projection on the ventral aspect between the palpifer and lacinia. The margins of these sclerites are closely adjacent and the projection of the stipes is usually concealed. The projection bears the palpus-like galea, which consists of a distinct proxagalea and a distagalea.

Draw the ventral aspect of a maxilla and name all the parts.
Draw the dorsal aspect of a maxilla and name all the parts.

Hydrous Triangularis.—The ventral aspect is convex and strongly chitinized. The dorsal aspect is flat and in great part membranous. The cardo is not subdivided and it is limited to the ventral aspect and is subtriangular in outline. The proximal end bears three projections, the short blunt blade-like projection is the entopartis. It bears a large premaxatendon. The exparartis is bifurcate, forming small projections. Each projection bears a tendon. The triangular area attached to the distal end of the cardo is the stipes. It forms a part of the lateral aspect and extends for a short distance onto the dorsal aspect. The subtriangular convex area located along the lateral margin of the stipes is the palpifer. It is located, except for its distal portion, on the dorsal aspect and bears the long maxillary palpus, which consists of four segments, the proximal one very short. The long linear polished area along the mesal margin of the punctured area also belongs to the subgalea. The projection borne at the disto-mesal angle of the subgalea is the lacinia. It extends along the mesal margin of the subgalea as a lighter colored area, separated from it by a furrow. The lacinia extends as a large semicircular area onto the dorsal aspect. The lacinella is small, strongly chitinized, membranous at its proximal end, with a distal lacinarastra. The lacinoidea is a broad blunt blade with a long stiff lacinarastra. The structure attached to the

distal end of the subgalea is the galea. It is connected with the subgalea and stipes by coria. The proxagalea is a triangular strongly chitinized area, separated from the distagalea by a broad coria. The distagalea is short, subcompressed, and chitinized on the dorsal and ventral aspects. The distal and mesal portions are covered with a galarastra of long stiff curved setae; the lateral aspect bears a tuft of yellow setae. The dorsal aspect is covered in great part by the maxacoria. It extends onto the proxagalea.

Draw the ventral aspect of a maxilla and name all the parts.

Pinotus Carolinus.—The ventral aspect can be identified by the long slender setae near the middle of its length. The cardo consists of a single irregular ventral piece. The distal portion is broad and strongly convex, the proximal part flaring. It forms the broadly emarginate exparartis. The entoparartis is the prominent projection on the mesal margin of the constricted portion. The trapezoideal area articulated to the distal end of the cardo and bearing long slender setae is the stipes. It extends onto the dorsal aspect as a small subquadrangular area. The subtriangular area located along the distal margin of the stipes is the palpifer. It bears long slender setae on the ventral aspect. The palpifer extends to the dorsal aspect where it forms a long narrow area. The maxillary palpus is attached to the distal end of the palpifer and consists of four segments; the proximal segment is geniculate. The area located along the mesal margin of the stipes and palpifer is the subgalea. It is bent so as to form a mesal aspect. The yellowish setiferous area on the dorsal aspect attached to the margin and distal end of the subgalea is the greatly reduced lacinia. The lacinella is a thin compressed lobe. The lacinoidea is a larger swollen lobe and each bears a lacinarastra. The broad densely setiferous lobe at the distal end is the distagalea. The dense covering of curved setae forms a large galarastra. The triangular area on the ventral aspect between the palpifer, subgalea, and distagalea is the proxagalea. The area of maxacoria on the dorsal aspect is not large.

Draw the ventral aspect of a maxilla and name all the parts.

Passalus Cornutus.—The ridged surface bearing long setae near the lateral margin is on the ventral aspect. The dorsal aspect is flat. The cardo is a long subcylindrical area, enlarged at the proximal end with a small exparartis and a somewhat larger entoparartis, bearing a premaxatendon. The distal end is bent at a right angle. The subtriangular area attached to the cardo is the stipes. Its surface bears long setae. The larger triangular area attached to the lateral margin of the stipes is the palpifer. Its surface also

bears long setae. The palpifer extends onto the dorsal aspect, where it is a large suboval area. The maxillary palpus, consisting of four segments, is attached to the distal end of the palpifer. The area along the mesal margin of the stipes and palpifer is the fused subgalea and lacinia. The distal end of the lacinia bears two long distant maxadentes and a lacinarastra of long straight setae on the mesal margin. The claw-shaped appendage attached between the lacinia and the maxillary palpus is the distagalea. The proxagalea is reduced by the close apposition of the palpifer and subgalea. The maxacoria and labacoria form the tube of which the cardo is a part.

Draw the ventral aspect of a maxilla and name all the parts.

Libellula Pulchella.—The caudal aspect is convex and chitinized. The cephalic aspect is membranous for the most part. The lateral aspect is distinct. The cardo is subdivided. The irregular proximal piece is the subcardo. Its proximal end is large. The exparartis is located at the meso-proximal angle. The entopartis is located at the latero-proximal angle and bears a small premaxatendon. The convex triangular distal area is the alacardo which extends onto the cephalic aspect and bears a number of setae. There is an oblique furrow separating the narrow distal portion of the subcardo from the alacardo. The convex area attached to the distal end of the alacardo with the longitudinal rows of setae is the stipes. The narrow area on the caudal aspect along the margin of the stipes is the subgalea. The stipes extends onto the cephalic aspect. The claw-shaped structure fused to the distal end of the stipes is the lacinia-like galea. The distal end bears five or six prominent spine-like teeth. The proximal half is convexly swollen and bears a galarastra. The lacinia is obsolete. The small convex area on the cephalic aspect near the disto-lateral angle of the stipes is the palifer. It is in part membranous. The long appendage covered with setae attached to the palpifer is the maxillary palpus. It consists of a single segment. The remaining appendage is sometimes considered as the fused lacinia and galea. It is the galea. The form and attachment of these structures would suggest that they represent the galea and lacinia and that it is the maxillary palpus that is obsolete.

Draw the caudal aspect of a maxilla and name all the parts.

Corydalus Cornutus.—The ventral aspect of the adult is convex and chitinized, the dorsal aspect is flat and only slightly chitinized. The attachment of the maxacoria and labacoria is limited to the cardo and the proximal end of the stipes. The cardo consists of a small proximal flat portion and a convex distal portion.

The parartis is represented by a slight concavity at the proximal end of the cardo. There is a small hump-like swelling near the parartis. The convex area on the ventral aspect attached to the distal end of the cardo is formed by a fusion of the stipes, palpifer, subgalea, and lacinia and the dorsal aspect is formed from the stipes, palpifer, and lacinia. The maxillary palpus consists of five segments and is attached by a broad coria to the disto-lateral angle of the fused area. The appendage mesad of the maxillary palpus is the galea. The proxagalea is submembranous with the distal end and the lateral aspect supported by chitinized plates. The distagalea is an attenuated submembranous lobe with the mesal half of its surface covered by a dense galarastra. The long slender pointed lobe mesad of the galea is the lacinia. A portion of the mesal part of the fused area also belongs to the lacinia. Its entire surface is covered with a dense lacinarastra.

Draw the ventral aspect of a maxilla and name all the parts.

Tabanus Sulcifrons.—The caudal aspect of the head ventrad of the foramen is closed by a membranous region containing two brownish chitinized areas. These brownish areas are the chitinized parts of the proximal sclerites of the maxillae. The mesal membranous area is a part of the labium, which is continuous with the labacoria. The maxacoria unites the lateral margin of each maxilla directly to the head. The small triangular sclerite articulated to the head laterad of a metatentorina is a cardo. It is subhorizontal in position. The proximal end is slightly enlarged into a parartis and the distal end is limited by a distinct transverse suture. The large elongate irregular shaped area distad of the cardo is the stipes. It is stiffened by a longitudinal infolding forming an ental plate. The lateral and mesal limits are indefinite, continuous with the labacoria and maxacoria. The distal portion is divided into two parts. The large swollen setiferous caudal portion which is free from the maxacoria and labacoria and directed ventro-laterad, is the palpifer. The suture separating the stipes and palpifer is obsolete. There is a long club-shaped setiferous maxillary palpus consisting of a single segment attached to the distal end of the palpifer. The cephalic portion of the stipes is connected with the maxacoria and labacoria. The infolded ental plate of the proximal portion is continued onto the cephalic portion. The distal end of the cephalic portion is continuous with a long thin light brownish lancet-shaped blade, the galea. It can be distinguished from the other piercing mouth-parts by its parallel sides and rows of minute teeth which are curved proximad. There is a minute brownish sclerite, which is located in the labacoria and attached to the proxi-

mal end of the galea. The free end articulates against the side of the hypopharynx. It is oval in outline with a tooth-like projection on one side. This is a rudimentary lacinia.

Draw a maxilla and name all the parts.

Benacus Griseus.—The maxillae, like the mandibles, are bristle-like in form and the distal portion is enclosed in the tubular labium. They differ from the mandibles, which have four or five recurved dentes at the distal end, in having a large number of seta-like dentes. The dextral maxilla bears only seta-like dentes, which are always more numerous than those on the sinistral and are always inclined distad. The sinistral maxilla in addition to the seta-like dentes bears about fifteen large dentes distad of the seta-like dentes. These large dentes as well as the seta-like dentes are inclined proximad or recurved. There is a distinct toothed notch in the region of the large dentes. The distal portions of the two maxillae are securely held together by the interlocking of the seta-like dentes. The distal end of the dextral maxilla rests near the toothed notch of the sinistral. The distal ends of the maxillae are sharply pointed and their lateral margins are finely crenulate. The proximal portion of each maxilla is attached to the ental surface of the head by a long chitinized ligament, which extends at right angles to the maxilla. The maxillae during their embryological development are subdivided into two parts as already described, one part forms the hemimaxilla and the other the bristle-like portion, here designated as the maxilla. It is considered as homologous with the galea.

Draw a maxilla and name all the parts.

Protoparce Sexta.—The greater part of the maxillae of this insect is modified into a tube several inches in length. This tube is coiled like a watch-spring and folded closely against the ventral aspect of the head. It is formed by the close apposition of the mesal surfaces of the two galeae. This surface of each galea is longitudinally furrowed and the apposition of the two furrows forms a tube. A cross-section of each galea shows a central cavity containing tracheae and other structures showing the connection of the cavity of a galea with the body-cavity. The surface of each galea is marked with V-shaped corrugations. The proximal ends of the galeae are located between the pilifers. The oblique transverse furrow on the caudal aspect at the proximal end of each galea and near the proximal end of the transverse corrugations is the suture marking the proximal limit of the galea. The small globular structure bearing long white simple scales and attached on the proximal

side of the suture marking the proximal limit of a galea, is a rudimentary maxillary palpus. The lacinia is obsolete. The long curved sclerite, to which the proximal end of each galea is attached and which bears a maxillary palpus, is a stipes. It is folded into a deep furrow formed by a thin plate-like extension of the ventral part of a postgena. The stipes can be pushed out of this furrow and the maxacoria attached to its cephalic margin identified. It is better to cut away the postgenae to expose the stipites. The caudal limit of each stipes is an oblique suture. This suture forms the ventral boundary of a subquadrangular area attached to the proximal end of the stipes. This area is the cardo. It is not as completely concealed by the plate-like extension of the postgena as the stipes. The dorsal and lateral boundaries of the cardo are distinct sutures.

Draw a cross-section through the proximal portion of the galeae.

Draw a ventral view of the head, showing the proximal parts of the maxillae, and name all the parts.

Draw a lateral view of the head, showing the galeae coiled on the ventral side.

5. LABIUM

The lower lip or labium is situated on the caudal or ventral aspect of the head, depending upon the direction of the mouth. It is attached to the head between the maxillae. The proximal portion on each side is continuous with the labacoria, and forms an important area for closing the mouth. The distal portion of the labium in biting insects is a loose flap. In most sucking insects it forms either a part of the puncturing apparatus or a tube for holding the puncturing blades or serves as a membrane for closing the ventral aspect of the head.

The labium is the appendage of the sixth head-segment. It arises in the embryo as a pair of appendages, similar in form to the maxillae. In the course of its development (Fig. 4, D-E, *li*), the mesal margins fuse and form the lower lip. The labium is in reality, therefore, a double organ, consisting of two maxillae-like structures fused on the meson. In certain arthropods as the Crustacea, there is no fusion at any time of this pair of appendages and they are known as the second maxillae. This name is retained by some entomologists for the labium of insects. The labium is also known as the lower lip in distinction from the labrum or upper lip.

The proximal end of the labium is continuous with the membrane connecting the head and thorax. This membrane, the cervix, is usually designated as the neck and contains, at least in generalized insects, distinct sclerites. The neck is here considered as a segment,

of which the labium is the appendage. The labium is not provided with artes and is consequently not articulated to the head or cervix in coilae as the mandibles and maxillae. The narrow area of corea located between each proximo-lateral angle of the labium and the head is a union of the labacoria and the cervacoria. The presence of this narrow area of coria on each side and the absence of artes shows that the labium is in its primitive position, attached to the cervix, at least in generalized insects. Some writers consider the neck as an additional body region and have named it the microthorax. The fact that the ganglion of the labial segment is fused with the ventral ganglion of the head and that the labium itself in specialized biting insects is fused with the head goes to show that the labium is closely affiliated with the head and the evidence is slight for considering the cervix as a distinct body-region. As a matter of convenience in studying the parts of this region, the appendage of the cervix, the labium, is discussed with the movable parts of the head, while the cervix is discussed with the thorax.

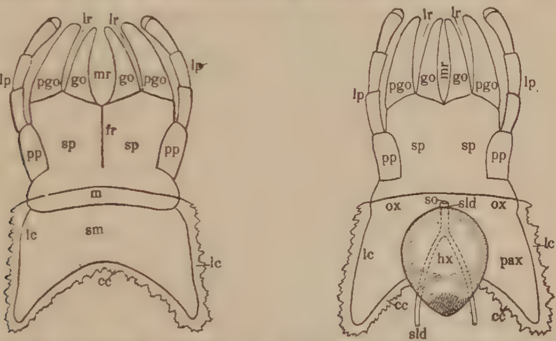

Fig. 7.—Hypothetical labium. A, ventral aspect ; B, dorsal aspect.

The three proximal sclerites of the labium, the submentum, mentum, and stipulae are homodynamous with the subcardines, alacardines, and stipites of the maxillae. They, therefore, represent the protopodite of the typical mouth-appendage. The paraglossae and glossae, wholly or for the greater part fused in most insects, are homodynamous with the galeae and laciniae. They, therefore, represent the endopodites. The labial palpi are homadynamous with the maxillary palpi and represent the exopodites. The following parts can be identified:—

Submentum.—The area forming the proximal portion of the labium (Fig. 7, *sm*) is the submentum. It is generally a large distinctly chitinized area, but may be entirely membranous and continuous with the labacoria and the membrane of the cervix, the cervacoria. Its lateral margins are continuous with the labacoria.

The submentum is limited to the ventral or caudal aspect of the labium. When the submentum is attached to a gula, the suture between the submentum and the gula, is the mentasuture. When the submentum is very long and narrow, as in isopteran insects, the caudal portion has been called the gulamental plate, with the thought that this part of the submentum represents a part of a gula.

Mentum.—The transverse area attached to the distal end of the submentum (Fig. 7, *m*) is the mentum. It is a small transverse area in generalized insects, may be obscurely indicated, and is frequently apparently wanting. In the latter case the mentum is fused with the stipulae. In certain specialized insects there is an area of considerable size, the stipulae, that has been incorrectly homologized as the mentum. The lateral margins of the mentum are connected with the labacoria. The mentum like the submentum may be entirely membranous. It is always limited to the ventral or caudal aspect of the labium.

Ligula.—The name of ligula is usually applied to all that portion of the labium, except the labial palpi, distad of the mentum. I have previously used it in a generic sense for this entire region, including the labial palpi. It has also been applied to the glossae, when they are fused and modified into a tongue for sucking. The use of this term is so varied, none of which coincide with the homologies here adopted, that it has been discarded in the following descriptions.

Stipulae.—The area (Fig. 7, *sp*) attached to the distal end of the mentum in most insects is a single large chitinized structure. Its lateral margins and distal end bear the appendages of the labium, the labial palpi, the paraglossae, and the glossae. The cuticle on the meson of the stipulae in many generalized insects is less strongly chitinized or is differently colored from the lateral portions. It is sometimes a distinct line and marks the place where the two halves of this area are fused. Each half is known as a stipula and each is homodynamous with a stipes. In certain generalized insects the line of fusion of the stipulae on the meson is not quite complete. In most insects the stipulae are completely fused and there is no indication of their double origin. The stipulae are not limited to the ventral or caudal aspect. They are also known as the eulabium, labiostipes, or labiosternite.

Palpiger.—The small area attached to the lateral portion of each stipula (Fig. 7, *pp*) is a palpiger. It is frequently so completely fused with the stipula that it can not be identified as a separate area. In some sucking and a few biting insects the palpiger is tubular, and is constricted at the proximal end. It has

been erroneously considered and counted as the proximal segment of the labial palpus.

Labial Palpus.—The segmented appendage attached to each palpiger (Fig. 7, *lp*) is a labial palpus. In those insects where the palpiger is fused with the stipula, the labial palpus is apparently attached to the stipula. It consists typically of three segments, never more than this number, but may be reduced to a smaller number or may be wanting. The distal end of the distal segment is frequently membranous and bears numerous conical setae, which are organs of special sense, tactile organs.

Paraglossa.—The appendage attached to the disto-lateral portion of each stipula (Fig. 7, *pgo*) is a paraglossa. It is homodynamous with the outer lobe or galea of the maxilla. The proximal end of each paraglossa in generalized insects is separated from the stipula by a distinct transverse suture. This suture is homodynamous with the suture between the distagalea and the proxagalea. The paraglossae are sometimes completely fused with the glossae and extend onto both surfaces of the labium.

Glossa.—The appendage (Fig. 7, *go*) attached to each distal end of a stipula, mesad of a paraglossa, is a glossa. It is homodynamous with the inner lobe or lacinia of the maxilla and extends onto both surfaces of the labium. The proximal end of each glossa in generalized insects is separated from the stipula by a distinct transverse suture. This suture is homodynamous with the suture between the stipes and lacinia. The two glossae may form a single appendage which is distinctly separated from the paraglossae in some biting insects or the fused glossae may be greatly elongated to form a long tongue in certain sucking insects. Such a structure is incorrectly designated as a glossa, as is usually done, if the mesal appendage of each stipula of a generalized labium is to be designated as a glossa.

Latarima.—The fissure separating (Fig. 7, *lr*) each glossa and paraglossa is a latarima. It is rarely wanting.

Mesarima.—The fissure separating (Fig. 7, *mr*) the glossae is a mesorima. The glossae are frequently fused and the mesorima obsolete.

Fundarima.—The proximal end of the fissure (Fig. 7, *fr*) between the glossae may be continued for a part of the length of the stipulae. Where the stipulae are completely fused, the position of the fissure is often indicated as a pale line or furrow. Such a fissure, line, or furrow is a fundarima and marks the line of fusion of the two stipulae. The fundarima is sometimes indicated only as a slight emargination at the distal end of the fused stipulae.

Alarima.—When the glossae are greatly reduced in size or wanting and the paraglossae are of considerable size, there is a fissure between the two paraglossae, which may be adjacent or not. This fissure may be narrow or broad, depending upon the form of the paraglossae and is known as the alarima.

Alaglossa.—The two glossae are completely fused into a single appendage in many insects and the mesorima is wanting. This single mesal structure is an alaglossa, which may be of ordinary length or may be longer than the head. It is also incorrectly known as a glossa or as a ligula.

Totaglossa.—The glossae and paraglossae are fused in certain insects into a single strongly chitinized piece and the latarimae and mesorima are wanting. Such a structure is a totaglossa.

Duplaglossa.—The glossae are usually modified into an alaglossa in hymenopterous insects. In certain wasps the distal end of the alaglossa is emarginate. This emargination may proceed until two long slender glossa-like structures are produced. Each may be as long as or longer than the head. Although they are tongue-like and folded close together, they are evidently not primary structures and should not be confused with the true glossae. Each is known as a duplaglossa.

Mecaglossa.—The glossae and paraglossae are sometimes so greatly reduced in size and so completely fused with each other and the stipulae in mecopterous insects, that they are considered as obsolete. Such a belief is increased by the fact that the palpigers are adjacent and are attached to the distal end of the labium. This condition is known as a mecaglossa.

Rostrum.—The labium is sometimes greatly elongated and its lateral margins are folded mesad until adjacent or nearly so, forming a tube open on one side in which the mandibles and maxillae, which are bristle-like or lancet-like, are enclosed. This type of labium is known as a rostrum. It is usually considered as being composed of a certain number of segments, which are numbered beginning at the proximal end. The parts of such a labium are rarely homologized. The distal segment of the rostrum has been homologized with the labial palpi.

Lateral Lobes.—The lateral margins of the submentum are sometimes greatly expanded and infolded, forming large rounded lobes which bound the mesal emargination and rest upon the maxillae. Such lobes are known as lateral lobes.

BLATTA ORIENTALIS.—The large proximal shield-shaped sclerite is the submentum. Its proximal and distal ends are broadly roundly concave. Their limits are marked by distinct sutures.

The oval sclerite attached to the distal end of the submentum and located for the most part in its emargination is the mentum. Each lateral margin of the submentum and mentum is deeply infolded and submembranous, rests upon a maxilla, and is continuous with the labacoria. The suture between the mentum and stipulae is distinct. The subcylindrical sclerite forming each lateral part of the proximal portion of the stipulae is a palpiger. Each palpiger bears a labial palpus consisting of three segments. The distal end of the distal segment is membranous and bears conical setae, organs of special sense. The mesal boundary of each palpiger is a brownish line, more distinct near the articulation of the labial palpus. It can be traced almost to the mentum. Each palpiger forms a prominent area on the dorsal aspect, where it is more easily identified than on the ventral aspect. The distal half of the fundarima is a fissure and the proximal half a furrow. Each stipula is an irregular area. The lobe attached to the disto-lateral portion of each stipula is a paraglossa. The distal portion is constricted and membranous. Its proximal boundary is a suture. The small elongate lobe attached to the distal end of each stipula mesad of a paraglossa is a glossa. Its proximal boundary is a suture. The latarimae and mesarima are distinct. The distal ends of the glossae and paraglossae bear areas of conical setae.

Draw the ventral aspect of a labium and name all the parts.

Draw the ventral aspect of the head, with the mouth-parts in place, and name all the parts.

Melanoplus Differentialis.—The crescentic proximal sclerite is the submentum. The proximal end is deeply concave and continuous with the cervacoria. The proximo-lateral portions are long and slender. Each rests upon a maxillaria adjacent to a metatentorina. The caudo-lateral angles are broadly convexly protuberant. The short neck-like area attached to the distal end of the submentum is the mentum. The mesal third of the sutures marking the proximal and distal extent of the mentum are obsolete. There are distinct furrows marking the position of the obsolete portion of the sutures. The furrows can not be identified in mounted specimens. Each lateral portion of the mentum bears a small group of conical setae. The lateral margins of the submentum and mentum are infolded and continuous with the labacoria. The stipulae constitute a considerable part of the labium. The elongate convex shoulder-like structure on each lateral part of the proximal portion of the stipulae is a palpiger. Each bears a labial palpus consisting of three segments. The distal end of the distal segment is membranous and bears conical setae. The sutures bounding each pal-

piger, except for a short distance at its disto-mesal angle, are obsolete. The sutures are represented by furrows on the lateral and the remainder of the mesal margin. The stipulae are fused and the fundarima, except its distal portion, is obsolete. The two large convex areas borne on the distal portion of the stipulae are the paraglossae. They are adjacent on the meson. The mesal margin of the sinistral paraglossa is provided with a ridge which fits in a groove in the mesal margin of the dextral paraglossa. The paraglossae and stipulae are separated by distinct transverse sutures. The lateral portion of each paraglossa and each stipula is dilated, forming a prominent area, which greatly increases the convexity of the labium. The glossae are minute. They are attached to the disto-mesal angle of each stipula. The dextral glossa is usually about three times as large as the sinistral and its distal end is located on the meson between the adjacent paraglossae. The latarimae and mesarimae are very short.

Draw the caudal aspect of a labium and name all the parts.

Draw the caudal aspect of the head, with the mouth-parts in place, and name all the parts.

Corydalus Cornutus.—The labium of the adult is protruded. The submentum is attached to the mesal half of the cephalic end of the pregula by the mentasuture. It is a brownish strongly chitinized sclerite consisting of two parts connected on the meson by membrane. Its lateral margins are infolded and its disto-lateral angles are blunt angular protuberances. The membranous area, subequal in length to the submentum and attached to its distal end, is the mentum. It is frequently completely retracted under the submentum and concealed. The more strongly chitinized transverse dorsal area connected on each side with the submentum is a part of the parapharynx. The membranous part of the parapharynx contains on each side a sinuate transverse bar. The labacoriae are connected with the submentum and the chitinized bars connecting the submentum and parapharynx. The palpigers form shoulders on each lateral portion of the proximal part of the stipulae. They are limited on the dorsal aspect by membrane and on the ventral aspect by a slight furrow, which is fairly distinct at the distal end. Each labial palpus consists of three segments with a minute membranous area at the distal end of the distal segment. The area between the palpigers belongs to the fused stipulae. The fundarima is represented by a fine ridge. The large lobes adjacent on the meson and continuous with the distal portion of the stipulae are the paraglossae. The latarimae and mesorima are obsolete. The fused glossae are represented by the small truncate mesal area on

the ventral aspect at the proximal end of the alarima. It is concealed on the dorsal aspect by the adjacent mesal margins of the paraglossae. The sutures separating the stipulae, paraglossae, and glossae are obsolete. The dorsal and ventral surfaces of the stipulae and paraglossae are submembranous.

Draw the ventral aspect of a labium and name all the parts.

Harpalus Caliginosus.—The labium is attached to the pregula. The suture between them, the mentasuture, is distinct. The brownish strongly chitinized proximal sclerite of the labium is the submentum. The distal margin is broadly deeply emarginate. The calyx on each side near the meson and near the bottom of the emargination and bearing a long seta is a setigerous puncture of the submentum. The whitish quadrangular submembranous structure situated in the emargination of the submentum is the mentum. The mentum can be contracted or extended by the muscles attached to its ental surface. There is consequently considerable variation in the length of the exposed part of the mentum and stipulae. The subcylindrical subadjacent brownish structures folded against the proximal half of the stipulae are the palpigers. They are attached to the stipulae by their proximal ends. The distal end of each bears a labial palpus consisting of three segments. The first segment is short, the second segment is long and bears several setae on its ventral margin and for this reason the labial palpus is said to be pleurisetose. The mesorima and fundarima and the sutures separating the paraglossae and glossae from the stipulae are obsolete. The fused glossae form a brownish alaglossa, which is trumpet-shaped and bears two large setae, the glossal setae. The latarimae are distinct for about one-half the length of the alaglossa. The paraglossae are swollen whitish bluntly pointed lobes with setae along their lateral margins. The labacoriae are attached to the lateral margin of the mentum and to the infolded lateral margin of the lateral lobes of the submentum.

Draw the ventral aspect of a labium and name all the parts.

Draw the ventral aspect of the head, with the mouth-parts in place, and name all the parts.

Calosoma Calidum.—The submentum forms the larger part of the labium. It is attached by a movable suture to the pregula. Each lateral portion is developed into a large lateral lobe. The mesal portion is squarely emarginate with a prominent angular projection on the meson of the cephalic margin, the tooth of the submentum. The calyx on each side in line with the mesal margin of a lateral lobe is a setigerous puncture of the submentum. The mentum is membranous and almost completely retracted under the

mesal emarginate part of the submentum. The short cylindrical structure located on each side of the tooth of the submentum is a palpiger. The transverse fold marking the distal boundary of the mentum is located near the proximal ends of the palpigers. The labial palpi consist of three segments. The second segment is long and bears four setae on its cephalic margin. The third segment is clavate and the distal end is membranous. The mesal brownish structure at the distal end of the labium is the alaglossa. Its distal end bears several long setae on each side of the meson, the glossal setae. The small pointed lobe located on each side of the alaglossa is a paraglossa. The mesorima and fundarima are obsolete. The latarimae are marked by slight furrows. The dorsal and ventral surfaces of the paraglossae and stipulae are finely densely setiferous. The labacoriae are attached to the lateral margins of the mentum and to the infolded lateral margins of the lateral lobes of the submentum.

Draw the ventral aspect of a labium and name all the parts.

Hydrous Triangularis.—All the parts of the labium exposed on the ventral aspect are strongly chitinized. The submentum is attached to the pregula by a flexible suture, the mentasuture. The disto-lateral angles of the submentum are concave. The mentum is the short transverse membranous area retracted under the distal end of the submentum. It is continuous with the fused membranous stipulae. The palpigers are short and cylindrical. Each is attached to the lateral margin of a stipula and projects from beneath the concave disto-lateral angles of the submentum. The labial palpus consists of three segments. The first segment is very short. The mesorima and fundarima are obsolete. The dark colored triangular area on the meson at the distal end is the alaglossa. The latarimae are filled with membrane. The large transverse convex area on each side of the alaglossa is a paraglossa. Their mesal margins distad of the alaglossa are sometimes adjacent. The distal half of the ventral surface of each paraglossa is densely setiferous.

Draw the ventral aspect of a labium and name all the parts.

Pinotus Carolinus.—The labium is joined to the cephalic end of the pregula by a flexible suture, the mentasuture. The submentum is strongly chitinized and bears long slender setae. Its proximal end is concave. The distal end is roundly emarginate. The lateral lobes are bluntly rounded. The lateral margin of each is oblique and its proximal end contains a distinct acetabulum. The mentum is fused to the stipulae without indication of suture. The stipulae are very irregular in form. Each palpiger is

a large brownish strongly chitinized subcylindrical structure. Its proximal end is fused to a stipula and the lateral margin of a lateral lobe. It articulates against the acetabulum of a lateral lobe. Each labial palpus consists of three segments. The segments are all different in size and shape and bear numerous long slender setae. The stipulae are fused and the fundarima and mesarima are obsolete. There is a strongly chitinized structure on the meson which supports the alaglossa. The latarimae are shallow. The paraglossae are large and compressed. The mesal surface of each is brownish, the lateral surface is concave. It is provided with a brownish strongly chitinized plate against which the palpiger and labial palpus are folded. The dorsal and ventral surfaces of the alaglossa and paraglossa, except the lateral surfaces of the latter, are densely setiferous.

Draw the ventral aspect of a labium and name all the parts.

Passalus Cornutus.—All parts of the labium are strongly chitinized. The largest area is the submentum which is attached to the gular bar and separated from it by a distinct infolded immovable suture, the mentasuture. The distal margin is deeply squarely emarginate with long bluntly pointed lateral lobes. The remaining sclerites are situated in the emargination of the submentum between the lateral lobes. The mentum is fused to the proximal end of the fused stipulae. The fundarima, mesorima, and latarimae are obsolete. The stipulae should be bent so as to expose the part retracted under the submentum. They extend only a short distance distad of the lateral lobes. The stipulae, palpigers, paraglossae, and glossae are fused into a strongly chitinized totaglossa. The labial palpi are articulated at the bottom of deep depressions. Each consists of three segments. The distal margin of the totaglossa bears a large pointed tooth on the meson and a smaller one on each side. There is also a brush of long setae on each side of the distal margin laterad of the mesal tooth.

Draw the ventral aspect of a labium and name all the parts.

Libellula Pulchella.—The large area forming the proximal portion of the labium on the caudal aspect is the submentum. Each proximo-lateral portion is prolonged as a strongly chitinized arm and fused to a postgena dorsad of a paracoila. The portion of the submentum included between the chitinized arms is membranous on the proximal half and continuous with the cervacoria. The suture at the distal end of the submentum is distinct. The distal portion of the labium is bent at right angles to the submentum. It forms a flap which covers the ventral aspect of the head. The

very narrow transverse area attached to the distal end of the submentum is the stipulae. The shield-shaped mesal area attached to the distal end of the stipulae is the totaglossa. The subquadrangular area continuous with each lateral end of the stipulae is a palpiger. Its shoulder bears long setae. The distal portion of each lateral margin of the submentum is emarginate and a projection of a palpiger articulates in the emargination. The labacoriae are attached to the lateral margins of the submentum and the proximal part of each palpiger. The large flap attached to the distal margin of each palpiger is the proximal segment of a labial palpus. Their mesal margins are dilated so that they meet distad of the totaglossa. The spine at the disto-mesal angle of each proximal segment of the labial palpus represents the greatly reduced second segment.

Draw the caudal aspect of a labium and name all the parts.

Benacus Griseus.—The labium is modified into a rostrum. The dorsal surface is longitudinally furrowed, forming an open tube for supporting the maxillae and mandibles. The labium consists of four parts or segments. The proximal part or submentum is concealed by being retracted in the head and covered by the labrum and hemimaxillae. It is subcylindrical, much longer on the dorsal than on the ventral aspect. The meson of the dorsal aspect is deeply concave. The epipharynx fits in the concavity. The second segment is the mentum. The distal portion is larger than the proximal and the median portion is distinctly constricted. The distal half of the dorsal surface is deeply longitudinally furrowed, the two free edges may be adjacent on the meson, forming the proximal part of the open tube. The third segment is formed from the fused stipulae. It is modified into an open tube continuous with that of the second segment. The sclerite attached on each side of the furrow of the dorsal aspect to the distal end of the fused stipulae is a palpiger. The labial palpi are wanting. The fourth segment is formed by a partial fusion of the glossae and paraglossae. It forms an open tube continuous with the third segment. The mesorima is obsolete. The alaglossa is truncate at the distal end. The projection on each side of the alaglossa, a paraglossa, is strong and obliquely pointed. The two paraglossae can be folded over the alaglossa and used as a piercing organ. The parts of the labium is this order are rarely homologized. They are numbered beginning at the proximal end.

Draw the dorsal aspect of a labium and name all the parts.

Euschistus Variolarius.—The rostrum consists of four parts

or segments. The proximal segment or submentum is the broadest. It is folded into the depression between the bucculae. Its dorsal aspect is broadly longitudinally concave. The labrum fits into this concavity. The second segment or mentum is more cylindrical and longer than the submentum. Its free edges are adjacent, forming an open tube continuous with that of the first segment. The third segment represents the fused stipulae and palpigers and the fourth segment the fused paraglossa and alaglossa. These segments are subequal in length and together shorter than the mentum. They form an open tube continuous with that of the second segment.

Draw the dorsal aspect of a labium and name all the parts.

Tibicina Septendecim.—The rostrum is short, held in place and supported by a projection on the cephalic part of the prosternum. The submentum is entirely membranous. It is a broad area, much broader at its proximal than at its distal end. It is united to the head and cervix by labacoria. The mentum or first segment is cylindrical. It is deeply longitudinally furrowed on the dorsal aspect. The labrum fits tightly into the sides of the furrow. The fused stipulae or second segment is short, about as long as the first. Its free edges are folded together and form an open tube continuous with the furrow of the first segment. This segment is formed by a fusion of the stipulae and palpigers. The distal or third segment is formed by a partial fusion of the paraglossae and glossae. It is similar in form, but smaller in diameter than the other segments. The paraglossae are separated from the alaglossa for a short distance at the distal end. This rostrum is described as having three segments. The segments are numbered and no attempt is ordinarily made to homologize them. The numbering of the segments given above is that given in the description.

Draw the dorsal aspect of a labium and name all the parts.

Protoparce Sexta.—The labium is greatly modified and is not labium-like in appearance. The adjacent parts of the postgenae should be removed so as to expose the labium. The submentum is membranous, continuous with the cervacoria and labacoriae, and located near the foramen. The fundarima, mesarima, latarimae, and alarima are obsolete. The brownish strongly chitinized U-shaped area on the caudal part of the ventral aspect is a part of the fused stipulae. This area is frequently incorrectly homologized as the gula. The lateral margins of each arm of the U is fused with the head. The cephalic end is fused with the caudal margin of a cardo. There is an appendage consisting of three segments attached to the cephalic part of each of the sides of the U, a labial palpus. The proximal segment is elongated and crescentic. The

second segment is shorter and broader than the first. It bears a minute globular papilla at its distal end, the third segment. The palpiger is obsolete. The membranous area cephalad of the U belongs to the fused stipulae, paraglossae, and alaglossa. The galeae, when coiled, are folded upon this region. Each lateral margin of this membranous area is fused with a cardo and stipes. The small black triangular area projecting under the proximal ends of the galeae is the alaglossa. The pointed end is free and projects caudad. The area on each side of the alaglossa is not well defined and represents a part of a paraglossa.

Draw the ventral aspect of a head showing the labium and name all the parts.

6. HYMENOPTEROUS MAXILLAE AND LABIA

The maxillae and labium in all hymenopterous insects are closely united into a single mass by broad areas of membrane. The submentum is greatly reduced in size and wholly or in part membranous. The mentum, which in generalized insects is a narrow transverse area, is considered as fused with and indistinguishable from the stipulae. The large area frequently designated as the mentum in hymenopterous insects is entirely different in form from the mentum of generalized insects and is the fused stipulae. The cervacoria has been divided into two portions by the mesal extension and fusion of the postgenae to form a genaponta. One portion is on the dorsal side of the genaponta and continuous with the cervix. The other portion, much smaller, is on the ventral side of the genaponta, the mentacoria, and is continuous with the labacoria located between the cardines.

It is feasible to study and identify the sclerites of the maxillae and labium independently, yet the interrelation and mechanism of the various parts can be understood much better, when they are considered together. This method has been followed here. It is impossible to get any conception of the relation of these appendages, if only specimens that have been flattened and mounted on slides, are studied. The specimens should be cleared and the appendages extruded and straightened. The head, except a small fragment to which the cardines are attached, should be removed. The loose flap of membrane attached to the proximal part of the cephalic aspect of the labium, a part of the parapharynx, should be removed. The directions are indicated as if the maxillae and labium were straight and directed ventrad. The following structures peculiar to hymenopterous maxillae and labia are present:—

Galcaria.—The caudal part of the mesal aspect of the proxa-

galea is frequently produced into a lobe. This lobe in the galearia. It is usually closely applied to the mesal aspect of the proxagalea. The distal end of the galearia is generally bluntly rounded and may project onto the distagalea. Its margins are fringed with setae.

Stipularia.—The proximal part of each stipula is greatly swollen on the caudal aspect and extends on each side into a prominent projection. Extending from this projection, there is a bar of varying length and width which articulates against the blunt proximo-caudal angle of the subgalea or against the stipes, with which it is connected by membrane. Each bar and its articular surfaces are known as a stipularia.

Glossaria.—The glossae are fused into a prominent alaglossa and the latarimae are always much longer on the cephalic aspect than on the caudal. The proximal portion of each latarima is occupied by a distinctly chitinized area. This area is a glossaria. It is usually marked as a small triangular, round, or linear area on the caudal aspect. The mesal ends of the glossariae are sometimes fused on the cephalic aspect.

Lora.—In certain genera of long-tongued bees, there is a brownish curved bar connecting the distal ends of the cardines. This bar is usually deeply concave on the meson, forming an acetabulum in which the proximal end of the submentum articulates. This bar, always a single piece so far as observed, is the lora. The lateral ends of the lora articulate against the caudal side of the proximal ends of the cardines. The origin of the lora has not been determined.

Sceliphron Caementarius.—The maxillae are broad and flat. The broad surfaces are on the lateral and mesal aspects. There is a deep depression between the distal portions of the maxillae, the bottom of which is formed by the labium.

Maxillae.—The cardines are club-shaped. The swollen proximal end of each is divided into a small exparartis and a large entopartis to which a premaxatendon is attached. The clear area near the disto-mesal angle of the ental surface is a cardacoila. The large convex area bearing stiff setae is the stipes. It is united to the cardo by membrane. The lateral margin and the adjacent part of the proximal end of the stipes is broadly rounded. The mesal edge of the caudal aspect is distinctly margined. The stipes is folded onto the mesal aspect, where it forms an elongate area, narrower on its distal portion. The proximal end bears a small cardartis. There is a membranous area on the caudal aspect at the distal end of the stipes to which the short subcylindrical palpifer is attached. The palpifer bears the maxillary palpus, which con-

sists of five segments. The broad compressed lobe with two brownish areas, attached to the distal end of the stipes, is the galea. Its union with the stipes is by a small area of membrane near the articulation of the palpifer. The proximal end of the galea is truncate, the free proximal angle is bluntly rounded. The proximal brownish area is the proxagalea, which is broadly connected by membrane with the distal brownish area, the distagalea. The lateral aspect of the proxagalea and distagalea, particularly the latter, is covered with setae. The disto-mesal part of the mesal aspect of the proxagalea is produced into a broad thin transparent lobe, the galearia. It extends nearly to the distal end of the distagalea and its cephalic margin is fringed with long stiff setae which are curved proximad. The distal end of the mesal margin of the stipes is fused with a small area which bears a bluntly rounded lobe. This small area is the subgalea and the thin bluntly rounded lobe is the lacinia. They are located adjacent to the truncate end of the galea. The lacinia is folded against the cephalic surface of the proxagalea. The large area of membrane attached along the margin of the lateral aspect of each maxilla is a maxacoria. It extends from the proximal end of the cardo to the proximal end of the subgalea.

Labium.—The submentum is in great part membranous. It unites with the combined labacoria and mentacoria to form the membranous area connecting the converging cardines. This membrane is continued between the stipites and contains a brownish chitinized V-shaped area on the meson, the strongly chitinized part of the submentum. This area is sharply pointed at its proximal end and deeply angularly emaginate at the distal end. The sides of the emargination are slender bars which articulate against the strongly chitinized area distad of them, the stipulae. The fundarima is obsolete. The fused stipulae are frequently identified as the mentum, which is fused with the stipulae. The brownish linear plate, a stipularia, continuous with each proximo-lateral portion of a stipula and extending through a labacoria, is attached to the cephalic margin of the mesal aspect of a stipes, to the proximal end of a stipula, and to the lateral margin of the mesal chitinized area of the submentum. The stipulae distad of the stipulariae are submembranous on the lateral aspect. The distal end of the mesal chitinized part of the stipulae is emarginate on each side of the meson. Each emargination is filled with membrane to which is attached a long subcylindrical palpiger. The labial palpus borne by each palpiger consists of three segments. The distal portion of the stipulae bears three submembranous lobes which are the large broad

alaglossa and the two small paraglossae. Each latarima extends to a small brownish triangular area, a glossaria. This extends along each lateral margin of the alaglossa through the bottom of the latarima to near the cephalic aspect. The alaglossa is flat on the caudal aspect and strongly convex on the cephalic. The latarimae extend farther proximad on the cephalic aspect and the paraglossae fit closely against the lateral surfaces of the alaglossa. The caudal aspect of the paraglossae and alaglossa is glabrous and the ventral margin of each bears a fringe of setae. The cephalic aspect is finely transversely striated and each striation bears a row of fine slender spinulae. The proximal portion of each paraglossa bears short stout hooked setae and the alaglossa short straight setae. The labium extends dorsad on the cephalic aspect to the stipulariae, where it is continuous with the membranous parapharynx. There are four brownish pad-like areas on this aspect near the proximal end of each paraglossa. The surface of each pad-like area is densely covered with short fine setae. There is a depression between the distal pair of pad-like areas in which is located the salivos.

Draw the caudal aspect of the maxillae and labium and name all the parts.

Draw the cephalic aspect of the maxillae and labium and name all the parts.

Vespa Maculata.—The maxillae are long and stout. The labium is a convex area firmly attached to the maxillae by membrane.

Maxillae.—The cardines are club-shaped. The proximal end of each is dilated into a parartis. The exparartis is smaller and shorter than the entoparartis near which a premaxatendon is attached. The distal half of each cardo is large, subtriangular, and setiferous. The disto-mesal angle bears a lighter colored area, the cardacoila. The distal ends of the cardines are subadjacent. The large area attached to each cardo is a stipes. Its proximo-mesal angle is a small cardartis. The caudal surface is convex and the lateral margin is sinuate, its proximal half extending onto the lateral aspect. The mesal margin is straight and the blackish chitinized mesal aspect meets the caudal aspect at a right angle, forming a vertical plate. The distal half of the mesal aspect is larger than the proximal. There is a small area of membrane at the disto-mesal angle of the caudal aspect, to which the subcylindrical twisted palpifer is attached. The distal portion is larger than the proximal and bears a maxillary palpus consisting of five segments. The distal end of the stipes is connected by membrane with a large compressed knife-like structure, the galea. The proxagalea is large and

comprises the greater part of the galea. The distagalea is a small triangular area joined to the proxagalea by membrane. The galea and stipes are bent at different angles. The long blunt blade-shaped lobe fused to the proximal portion of the caudal surface of the proxagalea is the galearia. The margin of the galea and its cephalic surface are covered with long slender setae. The setae along the mesal margin of the galearia are arranged in a row. The elongated brownish area connected by membrane to the mesal and lateral aspects of the distal end of the stipes is the subgalea. The thin plate-like blunt lobe attached to the subgalea is the lacinia. It is usually closely applied to the surface of the proxagalea.

Labium.—The submentum is entirely membranous and continuous with the membranous cervacoria and labacoria. The mentum is fused with the blackish chitinized area of the labium, the fused stipulae. They are connected on each side with a stipes by a continuation of the labacoria. Each lateral portion of the stipulae forms a large convex stipularia. There is a constriction filled with membrane on each side between the distal portion of a stipularia and a stipula. A subgalea articulates against the mesal end of each stipularia. A long slender subcylindrical palpiger is attached to each area of membrane and each bears a labial palpus consisting of three segments. Each lateral aspect of the stipulae is provided with a furrow in which a stipes fits. The sutures between the stipulae and the alaglossa and paraglossae are obsolete. The stipulae distad of the palpigers are more strongly chitinized. The mesal portion extends as a concave strongly chitinized area onto the proximal part of the concave trough-like alaglossa. The alaglossa is emarginate or bifurcate. The distal end of each portion bears a small round brownish area. It is from an emarginate type of alaglossa such as is found in this insect that the duplaglossae are developed. The latarimae are distinct. Near the middle of each lateral margin of the concave part of the alaglossa within a latarima, there is a small oblique linear brownish area, a part of a glossaria. Each glossaria extends through a latarima on the sides of the alaglossa as a prominent chitinized area. The glossariae fuse on the meson of the cephalic aspect and form a large brownish area. This is produced into two large blunt projections. Each projection is continued disto-laterad on the surface of the alaglossa as a light brownish band. The distal and proximal portions of the cephalic aspect of the alaglossa bear hooked setae. The cephalic surface also bears smaller setae. These are arranged in transverse rows and are replaced by spinulae on the proximal part. The small area between the distal projections of the glossariae also bears

hooked setae. There is a prominent pad-like area bearing hooked setae on the proximal end of each paraglossa. The labium extends on the cephalic aspect to the dorsal margin of the mesal brownish area of the glossariae where it is continuous with the membranous parapharynx. The proximal portion is a triangular membranous area with the apex toward the distal end. The parapharynx is swollen pad-like on each side of this triangular area. The mesal margin of each of these pad-like areas is margined with a comb-like fringe of cuticular projections. The transverse depression at the distal end of these converging combs is the salivos.

Draw the caudal aspect of the maxillae and labium and name all the parts.

Draw the cephalic aspect of the maxillae and labium and name all the parts.

APIS MELLIFERA.—The maxillae and labium of this insect are greatly elongated. The elongation is due not only to the great extension of the proximal sclerites, but to a corresponding extension of the distal sclerites.

Maxillae.—The cardines are long slender bars. The proximal end of each is enlarged and bifurcate, the small arm of the bifurcation is the exparartis and the large arm, to which a premaxatendon is attached, is the entoparartis. The distal end of each cardo is enlarged. The enlargement is occupied for the most part by a transparent area bounded by darker cuticle. The proximal end of this area is concave, forming a cardacoila in which a large lora articulates. The disto-mesal angle is rounded, the disto-lateral angle is acute. The large area attached to the distal end of each cardo is a stipes. Its proximo-mesal angle is produced into a cardartis. The continuous caudal and lateral aspects are convex. The mesal aspect is concave and placed at right angles to the caudal aspect. There is a row of long setae on the ridge separating them. The distal portion of the stipes is yellowish and obliquely furrowed on the lateral aspect. The distal end of this furrow is deeper and contains a minute sclerite, the palpifer. It bears a minute maxillary palpus consisting of a single segment. The long lanceolate area distad of the palpifer is the galea. The suture between the galea and stipes is obsolete. The mesal margin and the distal end of the galea are fringed with long setae. The very minute constricted area at the distal end may represent the distagalea. The galearia is obsolete. The lateral surface of the galea is convex. The mesal surface is concave and provided with a median thickening which bears a row of long setae. There is a long narrow black area or bar on the mesal aspect attached to the distal half of the

stipes. This bar is the subgalea. It bears a prominent membranous fold along its mesal margin. This is the lacinia. Each maxacoria is attached to the margin of a cardo and of a stipes as far as the proximal end of the subgalea.

Labium.—The lora is the strong bar, deeply concave on the meson of the caudal aspect, in which the blunt proximal end of the triangular submentum articulates. The labacoriae are continuous with each other and the cervacoria proximad of the lora and attached on each side to a cardo. The mentum is fused with the stipulae. The brownish structure distad of the submentum is the fused stipulae. The long flattened appendage attached to each lateral part of the subtransparent area at the distal end of the brownish stipulae is a palpiger. One surface is convex and the other concave. The concave surface is closely applied to the surface of the mesal structure, the alaglossa. Each palpiger bears a three-segmented labial palpus. Its proximal segment is much longer than the other segments, concave on the surface so that it can be applied to the surface of the alaglossa. The caudal margin of the concave surface of the palpiger and the proximal segment of the labial palpus are fringed with white setae. The subtransparent area located between the proximal ends of the palpigers is also a part of the fused stipulae. The suture separating the stipulae and alaglossa is obsolete. The alaglossa is cylindrical and as long as the combined stipulae and cardines. Its surface is closely transversely striated and each striation bears a row of spinulae. They are longer on the distal portion of the alaglossa. The distal end is constricted, forming a subglobular structure which is covered with branching setae, the flabellum. There is a furrow on the caudal aspect extending from the flabellum to the proximal end of the alaglossa. The alaglossa is U-shaped in cross-section. It is in reality a trough within a trough. The furrow marks the place where the margins of the trough are attached. The inner trough is an infolding of the surface of the alaglossa, which forms a lumen, the cibivia, through which liquid food can be passed. The outer trough is the ectal surface and supports the inner trough. The inner trough can be extruded through the furrow by the insect or by treatment with caustic potash. The alaglossa, when extended, is a figure 8 in cross-section. The latarimae are distinct. The minute dark spot on each side of the caudal aspect at the proximal end of the alaglossa and extending distad through a latarima as a brownish bar is a glossaria. The paraglossae are short and more or less concealed on the caudal aspect by the palpigers. They should be pushed aside and the paraglossae exposed. The mesal

surface of each paraglossa is concave and fits closely against the side of the alaglossa. The paraglossae are much larger on the caudal aspect than on the cephalic. Each stipularia is a narrow linear brownish bar which extends from a subgalea to a stipula. The salivos is located on the cephalic aspect in the depression at the proximal end of the alaglossa. The lip-like blunt projection located between the paraglossae guards the salivos.

Draw the caudal aspect of the maxillae and labium and name all the parts.

Draw the cephalic aspect of the maxillae and labium and name all the parts.

7. PROPHARYNX AND PARAPHARYNX

The portion of the alimentary canal extending between the foramen and the mouth is the pharynx. It is usually more or less trumpet-shaped, the small end directed toward the foramen and the large end toward the mouth. The pharynx is held in place by muscles or tendons which extend between it and the ental surface of the head. The alimentary canal caudad of the foramen is frequently suddenly enlarged. The mouth is considered simply as the external opening of the cephalic end of the pharynx, analogous to the anus which is the external opening of the caudal end of the alimentary canal. It differs from the anus, however, in that its contour is very irregular. In the following description and listing of parts, the mouth has been considered as directed cephalad and the cockroach has been taken as the type.

The cephalic and lateral margins of the labrum and clypeus form on the dorsal aspect the cephalic and lateral boundaries of the mouth. Each lateral boundary on the lateral aspect is formed by the proximal end of a mandible, the distal margin of a maxacoria, a stipes, and the distal margin of a labacoria. The ventral boundary is the proximal margin of the stipulae. There is a great variation in the size of the labrum and mouth-parts, in the extension and association of these parts, and in the size and length of the maxacoriae and labacoriae. It is the variation in the size and shape of these parts that produces the irregular contour of the mouth. In the specialized Diptera the mouth is apparently located distant from the margin of the head.

The labrum, the mandibles, the maxillae, and the labium are all structures which typically have a distinct internal space or cavity for the entrance of blood, tracheae, and nerves and are, therefore, continuous with the body-cavity. The cephalic end of the pharynx forms the ventral wall of the labrum; also the mesal wall of the maxacoriae, cardines, stipites in part, and labacoriae;

and the dorsal wall of the submentum and mentum. The cephalic flaring portion of the pharynx differs from the caudal portion, which is usually a tube of nearly uniform size, in other ways than simply that of shape. Its dorsal and ventral portions are more strongly chitinized and bear areas of setae and spinulae. They form the pathways along which the food passes to reach the tubular caudal portion of the pharynx. This flaring cephalic portion is the prepharynx and the tubular caudal portion is the postpharynx. The lateral portions of the prepharynx are membranous and usually not provided with special areas of setae and spinulae. This region is continuous with the maxacoria in great part and to a much less extent with the labacoria. It is also known as the ambipharynx. In most insects the dorsal and ventral portions of the prepharynx are distinctly modified and form an integral part of the masticatory apparatus. They are sometimes transformed into strongly chitinized lancets, that may be external in position and have a function similar to that of the mandibles and maxillae in certain sucking insects. These structures are not true mouth-appendages and have not been derived from such appendages. They are discussed at this point because of their close association with the true mouth-parts in sucking insects.

The dorsal portion of the prepharynx, the propharynx, is the part of the pharynx derived from the stomodaeum. The ventral portion of the prepharynx, the parapharynx, is derived in great part from the structures that originate on the external surface of the embryo, probably the sterna of the mandibular and maxillary segments. It comprises in addition to a small portion of the stomodaeum, the area of cuticle included between the mouth of the embryo and the labium. In the course of development the appendages attached to this area become closely associated and adjacent. As a consequence the cuticle located between the appendages is transversely folded and connected by the maxacoria and labacoria with the propharynx. The origin of the parts of the parapharynx is still in dispute. Embryologists seem to be fairly well agreed that one portion is derived from a median unpaired invagination located between the maxillae and that the other part is derived from thickenings located between the mandibles. Those insect embryologists who maintain that the head contains six segments, affirm that the parapharynx is derived from the sterna of the maxillary and mandibular segments, while those embryologists who maintain that the head contains seven segments, consider the parapharynx as derived from a pair of appendages which are represented in the embryo by a pair of neuromeres located between the neuromeres of the mandibular and maxillary segments. The parapharynx com-

prises all the structures ordinarily designated as the hypopharynx.

Preparations are easily made for the study of the propharynx and parapharynx. The head with a portion of the oesophagus attached should be removed. The head should be slit along the middle of each lateral aspect nearly to the mandibles and then placed in caustic potash until all the muscles are broken down. After this is completed, the specimen should be thoroughly washed, the greater part of the head-capsule removed, and the preparation placed in alcohol. The portions lining the labrum and the labium should be separated from these appendages and the mouth-parts removed. The pharynx should be slit along the middle of one lateral aspect and spread out so that its interior can be examined.

Pharynx.—The portion of the alimentary canal extending from the foramen to the mouth is the pharynx. It consists of a cephalic trumpet-shaped portion, the larger end of which is directed toward the mouth and a caudal tubular or enlarged portion which connects with the oesophagus. The pharynx is held in place by muscles or tendons which extend from it to the ental surface of the head.

Prepharynx.—The flaring cephalic portion of the pharynx, which is located adjacent to the mouth, is the prepharynx. The structures associated with the mouth-parts are located in this region. Its lumen is almost completely filled with folds of coria and is variously known as the oral cavity, the mouth-cavity, the mouth, or the buccal cavity. This is the masticatory portion of the pharynx. The folds make possible a considerable dilation of the coria and a consequent great increase in the size of the lumen. The caudal end is constricted and there is a transverse mouth-like slit or opening, controlled by imperfectly formed valves. This slit connects with the caudal region of the pharynx.

Postpharynx.—The caudal portion of the pharynx (Fig. 8, *pox*) is always tubular. It connects the prepharynx and the oesophagus and is known as the postpharynx. The prepharynx and postpharynx are easily identified in generalized insects.

Propharynx.—The dorsal portion of the prepharynx (Fig. 8, *pex*) is the propharynx. It is the pathway of the food on the dorsal surface of the pharynx in generalized biting insects. Its lateral limits are frequently marked by brownish cuticular lines. The propharynx usually consists of several distinct regions.

Parapharynx.—The ventral portion of the prepharynx (Fig. 8, *prx*) is the parapharynx. It is the pathway of the food on the ventral surface of the pharynx and its lateral limits are frequently marked by brownish cuticular lines. The parapharynx usually consists of several distinct regions.

Epipharynx.—The portion of the propharynx forming the ventral wall of the labrum (Fig. 8, *ex*) is the epipharynx. Its caudal extent is limited by the tormae, which are located at the lateral ends of the clypeo-labral suture. In certain sucking insects the labrum and epipharynx are greatly elongated, forming either a long slender projection or cuticular piercing blade. This fused structure is designated as the labrum-epipharynx. The portion of the propharynx designated as the epipharynx is frequently defined as the portion forming the ventral wall of the labrum and clypeus. Since the propharynx is never attached to the clypeus, it is omitted.

Epigusta.—The portion of the propharynx located caudad of the epipharynx and tormae (Fig. 8, *eg*) is the epigusta. Its caudal extent is limited by the transverse slit-like mandoris. The epigusta is strongly chitinized in certain insects. The two halves of its surface may be different in form. This asymmetry is due to the difference in the size and shape of the dentes of the two mandibles.

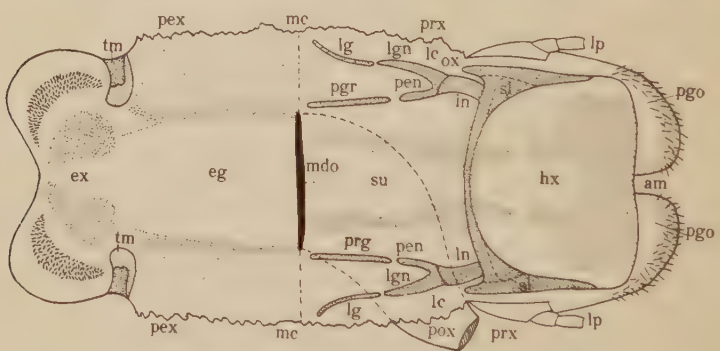

Fig. 8.—Hypothetical prepharynx.

Subgusta.—The membranous caudal portion of the parapharynx (Fig. 8, *su*) is the subgusta. Its caudal extent is the mandoris. This region is strongly chitinized in certain insects. The two halves of the subgusta may be asymmetrical. The asymmetry is due to the variation in the size and form of the dentes of the two mandibles.

Mandoris.—The mouth-like slit located between the prepharynx and the postpharynx (Fig. 8, *mdo*) is the mandoris. It is situated in generalized insects at the point where the epigusta and subgusta unite. In sucking insects the epigusta and subgusta are greatly reduced in size, forming a basipharynx with the mandoris located between the cephalic or ventral end of the basipharynx and the postpharynx.

Pharyngea.—The long slender sclerite (Fig. 8, *prg*) forming

the lateral boundary of the caudal part of each side of the subgusta is a pharyngea. It is also known as a pharyngeal sclerite.

Paralingua.—The short sclerite near the cephalic end of each pharyngea (Fig. 8, *pcn*) and in some insects forming a part of the lateral boundary of the cephalic part of each side of the subgusta is a paralingua. The pharyngea and paralingua of the same side are frequently fused, end to end, forming a single sclerite. This may be known as a pharyngea-paralingua. The sclerites described as the pharyngea and paralingua are combined by some writers and designated as the superlinguae, paraglossae, or maxillulae.

Linguacuta.—The long slender sclerite (Fig. 8, *lgn*) articulating against the end of the ventro-caudal extension of each paralingua is a linguacuta. The tendon attached to each linguacuta is a linguatendon.

Lingula.—The sclerite on each side supporting the caudal half of each lateral portion of the hypopharynx (Fig. 8, *ln*) is a lingula. Each is located cephalad of a paralingua with which it may be fused. The lingulae are sometimes fused on the meson. In specialized insects the pharyngea and paralingua and lingula of one side may all be fused, end to end, forming a single large sclerite. This may be known as the pharyngea-lingula.

Hypopharynx.—The swollen tongue-like portion of the parapharynx (Fig. 8, *hx*) of generalized insects is the hypopharynx, the maxillula or lingua of some authors. It is sometimes of considerable size and may be protruded from the mouth for some distance. In the Entopteraria, the hypopharynx is only rarely tongue-shaped and the region occupied by it, if present, is a flat or slightly convex area. In the Diptera the walls of the hypopharynx are strongly chitinized and compressed, forming a cuticular blade which is fully extruded and used as a piercing organ. It has here been called the labium-hypopharynx. The free end of the hypopharynx may be trilobed, as in certain Exopteraria. In such cases the median lobe is known as the lingua and each lateral lobe as a superlingua. Each lateral lobe is also known as a paraglossa, maxillula, or paragnath. The superlinguae are considered by those who believe that the head of an insect consists of seven segments, as representing a pair of appendages that are homodynamous with the mandibles and maxillae, between which they are located. Such writers are able to identify a galea, a lacinia, and a palpus in each superlingua.

Salivia.—The sclerite on each side supporting the cephalic half of the hypopharynx (Fig. 8, *sl*) is a salivia. Each is sometimes fused with a lingula. The cephalic ends of the saliviae are fre-

quently produced and fused on the meson, forming a structure for supporting the salivos.

Salivos.—The mouth of the duct of the salivary glands, which is located on the meson of the cephalic side of the hypopharynx (Fig. 7, *so*) in most Exopteraria is the salivos. In the Entopteraria, where present, it is located in the alaglossa or in the distal end of the hypopharynx.

Oscula.—The portion of the parapharynx cephalad of the hypopharynx and saliviae (Fig. 7, *ox*) is the oscula. In the Exopteraria, it is usually a definite area and generally forms the part of the dorsal wall of the submentum and mentum not covered by other structures. It is usually membranous. In the Entopteraria the oscula is continuous with the hypopharynx and difficult to identify.

Basipharynx.—The epigusta and subgusta are sometimes greatly reduced in size and form a slender strongly chitinized tube. This tube is the basipharynx. It is very different in form in the different orders and in some cases may extend as far as the mouth. The basipharynx may be depressed, as in most hymenopterous insects, and the pharyngeae and paralinguae can be identified along each lateral margin. In certain insects the basipharynx includes all the parts of the propharynx and parapharynx and the pharyngeae and paralinguae are obsolete. In the Diptera the basipharynx and paratorma together form the fulcrum of authors.

Cornua.—The lateral angles of the caudal end of the basipharynx are sometimes extended and form prominent projections as in many dipterous insects. These projections are the cornuae. Those on the cephalic side are the precornua or anterior cornu and those on the caudal side the postcornua or posterior cornu.

Salituba.—The salivary duct near where it joins the proximal end of the hypopharynx in certain dipterous insects, is enlarged and strongly chitinized. This swollen chitinized structure is globular or subcylindrical in form and is known as the salituba. It is also known as the salivary bulb.

Antlia.—The postpharynx in dipterous insects is greatly dilated near the dorsal end of the basipharynx. This dilated portion is the antlia. It is usually connected with the basipharynx by a membranous portion containing the mandoris. The antlia and basipharynx are usually placed at right angles to each other. The antlia is also known as the oesophageal pump.

Labraria.—The cephalic part of the epigusta in hymenopterous insects forms a prominent closely folded transverse lobe or lip which is folded against the epipharynx. This lip is the labraria. It

is frequently supported by a pair of prominent transverse sclerites. The labraria is generally designated as the epipharynx.

Labrecula.—The entrance to the basipharynx on the cephalic side in hymenopterous insects is guarded by a small transverse lip, the labrecula. It is always concealed by the much larger labraria and is frequently fringed with spinulae.

Infunda.—The salivos in hemipterous insects is located on a chitinized globular swelling, the infunda. Its external walls are formed by the fusion of the mesal parts of the saliviae and its internal part by an enlargement and chitinization of the ventral end of the salivary duct. It is also known as the salivary injector or salivary pump. The infunda is held in place by the metatentorium which is fused to each side.

Plumbilis.—There is a plunger-like cuticular rod projects from the dorsal end of the infunda, the plumbilis. Its dorsal end is bifurcate, each arm is expanded and serves for the attachment of muscles. The expanded arms are the tendons, the plumbatendons, and the plumbilis the plunger of the infunda.

Blatta Orientalis.—The epipharynx is flat. The tormae are distinct brownish sclerites. The lateral portion of each is a transverse bar connecting with a lateral end of the clypeo-labral suture. The bar is continuous with a mesal bar enclosing a circular clear area. There is a brownish chitinized area continuous with the cephalic portion which bears short subdecumbent spine-like setae. The epigusta is long and concave. The surface of the epipharynx, except adjacent to the brownish setiferous area, and of the epigusta are densely covered with short fine spinulae. The mandoris is as wide as the epigusta. The subgusta is flat or slightly convex and its surface is sparsely covered with spinulae. A long slender bar extends along each lateral margin. The faint constriction near the middle of the length of each bar marks its division into two sclerites. The caudal portion is a pharyngea. Its caudal end is dilated and supports one side of the mandoris. The cephalic portion of the bar is a part of a paralingua. Its cephalic end is continuous with the rather large subcrescentic area extending onto the lateral aspect. This area is also a part of a paralingua. The slender brownish bar articulating against the caudal end of the subcrescentic portion of each paralingua is a linguacuta. The brownish area continuous with the cephalic end of each paralingua is a lingula. Each lingula extends as a slender bar to the meson and fuses with the lingula of the other side. The large subquadrangular tongue-shaped structure of which the lingulae are part of its support, is the hypopharynx. Its dorsal surface is convex and densely covered with spinulae. The

ventral surface is concave. The prominent brownish area on each lateral aspect of the hypopharynx is a salivia. The caudal end of each salivia extends ventrad as a slender bar to the meson where it fuses with the salivia of the other side. The fused ends of the saliviae support the salivos. The short membranous area adjacent to the salivos and continuous with the labacoria and stipulae is the oscula. The maxacoria and labacoria connect the propharynx and parapharynx and are glabrous.

Draw the propharynx and name all the parts.
Draw the parapharynx and name all the parts.

Melanoplus Differentialis.—The epipharynx coincides in extent and shape with the labrum. The surface is concave. The dorsal portion is supported by an inverted Y-shaped thickening. The long brownish transverse club-shaped structure located at each lateral end of the clypeo-labral suture is a torma. The epigusta is comparatively short. The epipharynx bears a semicircular band of long yellowish spinulae about the stem of the inverted Y. Adjacent to the outer margin of this band of spinulae and extending to the mesal end of each torma, there is a band of setae. There is another band of spinulae on each side located midway between these setae and the lateral margin of the epipharynx. There is also an oblique band on each side of the distal emargination of the epipharynx. The dorsal ends of the semicircular band of spinulae are continued dorsad onto the epigusta. The bands of setae adjacent to the lateral margin of the spinulae are also continued. The pores located on the epigusta between the bands of spinulae are taste-pores. The mandoris is a large transverse opening. The broad area with a mesal furrow and fringed on each side with a band of long spinulae is the subgusta. Its sides are convergent ventrad. The narrow bar-like sclerite along each side of the dorsal part of the subgusta is the continuous pharyngea and paralingua. The cephalic portion of each bar is angular and extends into and supports the side of the mandoris. The short angular portion is a pharyngea and the remainder is a paralingua. Each paralingua is continued caudad along the maxacoria as a bar. The linguacutae, which are not well developed, articulate against the bar of the paralinguae. The short sclerite at the ventral end of each paralingua is a lingula. The two lingulae are much closer together than the paralinguae. The brownish bar extending ventrad from each lingula around the margin of the tongue-shaped structure, the hypopharynx, is a salivia. The saliviae meet on the meson at the ventral end of the hypopharynx, where they form a support for the salivos. The hypopharynx is semiglobular, flattened on the cephalic aspect.

The pathway of the food is marked by the bands of brownish spinulae, which are prominent and connect with those on the subgusta. There are also spinulae located between the lateral bands. The lateral and ventral surfaces are sparsely setiferous. The oscula is limited to the area on each side of the salivos.

Draw a propharynx and name all the parts.
Draw a parapharynx and name all the parts.

Libellula Pulchella.—The epipharynx is of the same size and shape as the labrum. Its cephalic margin and each lateral third is setiferous. The mesal third is differently colored and bears setae which are curved mesad. Each seta is placed on a prominent cylindrical base. The black area at each lateral end of the clypeo-labral suture is a torma. It shows externally as a small oval area. Each torma extends mesad as a slight thickening and near the meson is expanded into a large blackish projection which serves as a buffer for a mandible. Its free end is yellowish in color, due to a brush of spinulae. The surface of the epipharynx is convex between these projections and bears two converging rows of cylindrical elevations, the dorsal elevations bear setae. The epigusta is strongly chitinized and its lateral margins, particularly the caudal half of each, are strongly convergent to the mandoris. The subgusta, as well as its bounding sclerites, is very short. The transverse brownish strongly chitinized plate supporting the caudal side of the mandoris is the fused pharyngeae. The small brownish plate at each ventro-lateral angle of the pharyngeae is a paralingua. The surface adjacent to each paralingua is convex and bears cylindrical elevations. The linguacutae are inconspicuous. The lingulae are long. They are fused and indistinguishable from the saliviae, which form the lateral and ventral boundary of the tongue-shaped hypopharynx. The saliviae support the hypopharynx, extend as a chitinized band across the caudal side of its dorsal end and on the meson support the salivos. The membranous oscula is continuous with the labacoriae and stipulae. The hypopharynx is large, compressed, tongue-shaped, and bears numerous long curved setae, particularly around the ventral margin. The maxacoriae are greatly constricted adjacent to the mandibles and greatly expanded cephalad of them.

Draw the propharynx and name all the parts.
Draw the parapharynx and name all the parts.

Corydalus Cornutus.—The epipharynx is of the same size and shape as the labrum and its surface is brownish and as strongly chitinized as the labrum. The tormae are the narrow plates located at each lateral end of the clypeo-labral suture. The epigusta is

broad. The epipharynx and epigusta bear promiscuously arranged setae, more numerous on the epipharynx. The continuity of the epigusta and maxacoria is marked. The caudal end of the epigusta is constricted at the mandoris. The subgusta is a broad area similar in structure to the epigusta. The long slender sclerite extending along each lateral margin of the subgusta is a fused pharyngea and paralingua. The cephalic half represents a paralingua. There is a group of conical elevations on the mesal side of each paralingua. The transverse brownish chitinized plate which extends across the meson near the cephalic ends of the paralinguae represents the fused lingulae. The brownish longitudinal plate extending cephalad from near the ventral end of each lingula and the cephalic end of a paralingua is a salivia. The distal ends of the saliviae are distant and do not support the salivos. The caudal end of each salivia extends through a labacoria and fuses with the lateral margin of the submentum. The hypopharynx is the more or less flat area, not tongue-shaped, located cephalad of the lingulae and between the saliviae. The lateral portions are convex, forming slight ridges. The surface of the ridge is setiferous. The division between the hypopharynx and the dorsal surface of the lingula is a transverse glabrous area. The salivos is located on the dorsal side of the alaglossa.

Draw the propharynx and name all the parts.
Draw the parapharynx and name all the parts.

Harpalus Caliginosus.—The epipharynx is of the same size and shape as the labrum. There is a minute notch at each lateral end of the clypeo-labral suture. The oval brownish sclerite adjacent to each notch is a torma. Each is connected with the invaginated lateral ends of the clypeo-labral suture. The line connecting the tormae marks the caudal extent of the epipharynx. It consists of three parts, a triangular concave brownish mesal area and a lighter colored lateral area on each side. The mesal area bears a comb of blunt stout subdecumbent setae along each lateral margin which are directed mesad. The remainder of this area is covered with promiscuously arranged similar setae which are more abundant on the cephalic portion. The cephalic half of the lateral margin of each light colored area is fringed with setae. The epigusta is short and broad. The cephalic portion of the epigusta near the mesal triangular area of the epipharynx is convex on each side of the meson. Each convexity bears a dense brush of spinulae with two rows of pores along each lateral margin. The convexities are supported by the triangular areas at the caudal end of the mesal area of the epipharynx. There is a broad area of spinulae located just

caudad of the lateral convexities. The mandoris is located caudad of this spinulate area. The maxaeoria extends far laterad on each side between the labrum and a mandible and between a mandible and a maxilla. The pharyngeae are fused on the meson, forming a crescentic sclerite, the ends of which extend into the epigusta, and support the mandoris, which is on the concave side of the sclerite. The paralinguae, linguacutae, and lingulae are obsolete. Each salivia is represented by a slender sclerite which is fused to the infolded mesal margin of a lateral lobe. The short longitudinally folded area cephalad of the pharyngeae represents the combined subgusta and hypopharynx. The latter is longitudinally ridged with a mesal depression and never tongue-like. The hypopharynx is separated from the stipulae by a deep transverse fold. The salivos can not be identified. The duct of the salivary glands could not be found and is considered as wanting. The osculae are wanting.

Draw the propharynx and name all the parts.
Draw the parapharynx and name all the parts.

Vespa Maculata.—The labrum is retracted caudad of the clypeus and rarely more than the distal end is exposed externally. It can, however, be extruded for almost its entire length. The broad area of coria between the dorsal margin of the infolded wall of the clypeus and the tongue-shaped labrum is an expansion of the clypeo-labral suture. The transverse sclerite at each dorso-lateral angle of the labrum is a torma. The epipharynx is of the same size and shape as the labrum and with it forms a labrum-epipharynx. The ventral portion of the epigusta is modified into two transverse folds or lips. The cephalic and larger of these lips is the labraria. It can be identified from the presence of the minute mesal tongue-like projection on its ventral margin. The labraria forms a large closely folded area adjacent to the epipharynx and is supported by two prominent transverse brownish areas. The small transverse lip situated caudad of and under the labraria is the labrecula. Its margin is fringed with long flattened spine-like spinulae. The dorsal portion of the epigusta and subgusta form a long flattened basipharynx. The lateral margins of the basipharynx converge dorsad and each is supported by a long slender sclerite. The ventral portions are expanded, dilated, and form a large continuous transverse plate near the ventral end of the subgusta. The bar of each side represents the fused pharyngea and paralingua and the dilated portion of the lingula. The entire sclerite of each side is a pharyngea-lingula. The mandoris, located at the cephalic ends

of the pharyngeae, is not constricted. The hypopharynx is the convex area adjacent to the labrecula and is not tongue-like. It is submembranous and continuous with the oscula and the portion of the stipulae on the cephalic aspect. Each side of the hypopharynx is supported by a long slender curved brownish bar, a salivia. The dorsal end of each salivia articulates against a torma and a lateral angle of the labrum and the ventral end articulates against a subgalea and a stipularia. The salivos is located in the stipulae near the proximal end of the alaglossa where it is supported by a chitinized plate.

Draw the propharynx and name all the parts.

Draw the parapharynx and basipharynx and name all the parts.

Apis Mellifera.—The labrum is exposed and attached to the ventral margin of the clypeus. The epipharynx is of the same size and shape as the labrum. The tormae are small and transverse. The ventral portion of the epigusta is a swollen transverse fold, the labraria. The dorsal portion forms with the dorsal part of the subgusta a flattened basipharynx. The labraria is the tongue-like lobe located caudad of the epipharynx. There is a prominent ridge on the meson of the ventral aspect. This ridge extends onto the cephalic aspect. The dorsal end is produced into a minute tongue-like structure. The ventral portion of the labraria on each side of the ridge is provided with prominent sense-pores. The labraria has been incorrectly described as the epipharynx. The labrecula is the slight transverse glabrous fold or lip that guards the entrance to the basipharynx. The basipharynx is flat and the sides converge dorsad. Each side is supported by a long slender sclerite. The ventral portion of each sclerite is dilated and forms a transverse plate. The bar of each side represents the pharyngea and paralingua which are fused end to end. The dilated portion is a lingula, the pharyngeal plate of students of this insect. These three sclerites are known as the pharyngea-lingula. The dorsal end bears two groups of sense-pores. The ventral ends of the fused lingulae project through the opening in the basipharynx and form a prominent brownish chitinized area upon which the labrecula rests. The lateral margin of the cephalic portion of the fused lingula converge ventrad. The ventral end of this area is free for a short distance and the ventro-lateral angles are extended as spine-like projections. The membranous area, which bears the ventral portion of the lingulae and which is longitudinally furrowed, is the hypopharynx. The membranous oscula is continuous with the fused stipulae. The sides of this area are supported by linear saliviae, which extend from near the labrecula to and articulate

against the subgaleae and stipulariae. The salivos is located on the cephalic surface of the stipulae near the proximal end of the alaglossa.

Draw the propharynx and name all the parts.

Draw the parapharynx and basipharynx and name all the parts.

TIBICENA SEPTENDECIM.—The labrum is the strongly convex projection borne by the clypeus. The epipharynx is strongly concave and forms with the labrum a thin chitinized trough, the labrum-epipharynx, for holding the bristle-like mandibles and maxillae. It extends to the edge of the infolded ventral portion of the clypeus. The tormae are obsolete. The epigusta is a long area. It consists of three portions. The ventral portion is concave, the concavity is bounded on each side by a ridge continuous with the lateral margin of the epipharynx. The dorsal portion is membranous. There is a mesal ridge with closely placed brownish spots at regular intervals on the top of the ridge. These spots are the ends of the long slender tendons of the pharyngeal muscles. The mesal ridge is bounded on each side by a brownish thickening continuous with one of the lateral ridges of the ventral portion. Each of these thickenings extends to the strongly chitinized concave-convex structure, the basipharynx. The dorsal portion of the epigusta is submembranous between the thickenings and the lateral margins of the clypeus. The third portion of the epigusta extends ventrad, forms the concave wall of the basipharynx and combines with the subgusta which forms the convex side. The mandoris is located at the dorsal end of the basipharynx and the ventral end of the postpharynx, between the chitinized portion and the membranous tube. The convexity of the epigusta fits closely into the concavity of the basipharynx. There is a large area on each side which is continuous with the infolded mesal margin of a jugum. The basipharynx is uniformly chitinized, formed by the fusion of the pharyngeae and superlinguae. The snout-like projection ventrad of the subgusta is the hypopharynx. It is uniformly chitinized like the basipharynx, formed by the fusion of the lingulae and saliviae, and is not tongue-like. The minute strongly chitinized protuberant globular structure on the caudal side of the hypopharynx is the infunda. The plumbilis is distinct and the plubatendons large. It is not located in the lumen of the pharynx. The duct of the salivary glands is attached to the ventral end of the caudal side of the infunda and opens into its lumen. The salivos is located at the ventral end of the tubular projection of the hypopharynx. This projection rests upon the concave surface of the epipharynx. The tube connecting the salivos with the infunda is

easily identified within the cuticle of the hypopharynx. The proximal part of the lateral margins of the basipharynx is continuous with the metatentoria. The distal portion is continuous with the convex membranous submentum and chitinized mentum.

Draw the caudal aspect of the propharynx and name all the parts.

Draw the lateral aspect of the basipharynx and name all the parts.

Benacus Griseus.—The parts of the propharynx and parapharynx are greatly elongated both externally and internally. The smooth surface forming the ventral wall of the labrum is the epipharynx. The surface of the labrum is transversely corrugated. The projection formed from the combined labrum and epipharynx is the labrum-epipharynx. The minute brownish or opaque areas located on the dorsal aspect near the lateral ends of the clypeolabral suture are the tormae. The large longitudinal convex area extending caudad from the epipharynx is the dorsal part of the epigusta. The epigusta bears two ridges, one on each side of the meson. There is a row of long fine tendons attached along the ental surface of the meson, the pharyngeal tendons. The ridges converge caudad and are densely covered with spinulae. The ventral part of the epigusta combines with the subgusta in the formation of a long strongly chitinized basipharynx. The cephalic end of the basipharynx is located beneath the cephalic end of the clypeus. The dorsal surface is deeply concave. The ventral surface is convex and uniformly chitinized, trough-like. The mandoris is located at the caudal end of the basipharynx beneath the caudal end of the clypeus. The cephalic half of the postpharynx is concave-convex and chitinized. The pharyngeae, paralinguae and lingulae can not be identified. The dorsal surface of the basipharynx is a glabrous strongly chitinized concave area. It terminates at its cephalic end in a flat structure consisting of three fine adjacent projections, the mesal projection longer than the lateral. This triradiate structure and the area ventrad of it is the hypopharynx. When the labrum-epipharynx is turned to one side and the jugae spread apart, the proximal segment of the rostrum is exposed. The mesal surface of each juga bears a stout thickening against and upon which the cephalic end of the hypopharynx rests. A distinct transverse cavity can be identified when the cephalic end of the hypopharynx is raised. The lateral margins of the hypopharynx are continuous with the adjacent infolded edges of the juga. The chitinized plate connecting the thickenings of the jugae and located ventrad of the hypopharynx is the oscula. The salivos is located in the mesal projection of the cephalic end of the hypopharynx. The cup-shaped structure located internally and ventrad of the hypopharynx is

the infunda. There is a very large cuticular ligament attached to each side of the infunda. Each ligament represents a metatentorium. The plumbilis is not large, but plunger-like and prolonged as a single cuticular plumbatendon. The ducts of the salivary glands are attached separately to the ventral surface of the infunda. In well cleared specimens the duct leading from the infunda to the salivos can be seen through the cuticle.

Draw the ventral aspect of the propharynx and name all the parts.
Draw the lateral aspect of the basipharynx and name all the parts.

TABANUS SULCIFRONS.—The labrum forms one side, the cephalic, of a long thin blade. The epipharynx forms the caudal side of the same blade. This thin piercing blade is known as the labrum-epipharynx. Its cephalic surface is convex and the caudal concave. There are two thickenings which extend lengthwise throughout its length. These converge and meet at the distal end. They are joined to the proximal end of a semiglobular mesal swelling. There is a small transverse sclerite on each side, the mesal end of which articulates against the globular swelling. Each of these sclerites is a torma. The epigusta extends dorsad as a concave subchitinized area and combines with the convex strongly chitinized subgusta to form a compressed concave-convex basipharynx. There are numerous muscle fibres attached to the surface of the epigusta. The dorso-lateral angles of the basipharynx are prolonged into prominent spine-like cornua. The constricted membranous area at the dorsal end of the basipharynx near the cornua is the mandoris. It is connected with the chitinized portion of the postpharynx, the antlia. This extends at a right angle to the basipharynx and has the dorsal aspect, to which muscles are attached, concave, and has the convex ventral surface membranous. The postpharynx is greatly reduced in size and normal in structure caudad of the antlia. The salivary duct is expanded into an elongated strongly chitinized salatuba, which is attached to the basipharynx near the ventral end of its caudal surface. The caudal surface of the salatuba is convex and the cephalic surface, to which muscles are attached, is concave. The lumen of the distal portion of the salatuba is restricted to a tube. It extends into the hypopharynx, which is a strongly chitinized blade capable of being closely applied to the caudal surface of the labrum-epipharynx. This tube extends through the hypopharynx and the salivos is located at its distal end. The position of the tube as a mesal band within the hypopharynx is easily identified. The caudal surface of the hypopharynx is convex and the cephalic concave. The epipharynx is closely applied to the hypopharynx, forming a lumen which connects with the basi-

pharynx. The pharyngeae, superlinguae, lingulae, and salivae are fused to form the basipharynx and hypopharynx. The caudal surface of the submentum is occupied by the oscula. The mouth is located between the labrum-epipharynx and the hypopharynx at their proximal ends and at the ventral end of the basipharynx.

Draw the lateral aspect of the propharynx and parapharynx and name all the parts.

Draw the caudal aspect of the prophaynx and parapharynx and name all the parts.

Protoparce Sexta.—The entire propharynx and parapharynx are modified into a basipharynx. The small white area forming the caudal wall of the central part of the labrum is the epipharynx. It is membranous and protrudes as a small white margin around the periphery of the labrum. There is a small quadrangular brownish area in the propharynx near the dorsal end of the epipharynx and a small setiferous area laterad of this brown area. The epigusta is the large white membranous area extending dorsocaudad for a short distance as the cephalic half of a tube with straight sides and then expanding into a large concave cordate area. The dorsal part of the parapharynx is a large concave strongly chitinized area, which rests upon but is not fused with the pretentoria. The concave membranous part of the epigusta forms the cephalic wall of this region of the parapharynx. The ventral part of the parapharynx is strongly chitinized and forms the caudal side of the tube of which the epigusta forms the cephalic. The parapharynx is uniformly chitinized throughout and it is impossible to identify the pharyngeae, superlinguae, lingulae, and saliviae. The concave area represents the subgusta and the region ventrad of it, forming the chitinized side of the tubular part, is considered as the hypopharynx. The black triangular area located between the proximal ends of the galeae is the alaglossa. This area forms the ventral side of the salivos and extends into the salivary duct, which is very large; about three times the size of the postpharynx. This plate has been incorrectly described as the hypopharynx. The cephalic end of the hypopharynx is a truncate chitinized area which projects over the salivos, but there is a transverse membranous fold between the salivos and the cephalic end of the hypopharynx, marking the line of fusion of the paraglossae and alaglossa with the hypopharynx.

Draw the dorsal aspect of the propharynx and parapharynx and name all the parts.

Draw the hypopharynx and alaglossa and name all the parts.

8. DIPTEROUS MOUTH-PARTS

Most of the sclerites of the mouth-parts of dipterous insects are easily homologized with those of generalized insects. There has been not only a great reduction of certain parts but also a massing together of those parts that have been retained. The difficulty in homologizing parts arises because of the presence of several secondarily developed structures. The identity of the various sclerites can be determined more readily, if all the parts of the maxillae and labium are described together. The mandibles, maxillae, propharynx, and parapharynx of the tabanid have already been described. These should be studied before proceeding with the labium, which is included here, because the structures of this insect serve as an excellent introduction to the study of the other species of Diptera described. The heads should be removed and soaked for twenty-four hours or more in a weak solution of caustic potash, not over five per cent, better less. If the mouth-parts are retracted, even after continued soaking, they can be extruded by applying pressure to the cephalic aspect of the head. The relation of the parts are better understood from a study of specimens in alcohol, but some of the sclerites are very small and there should be a good series of mounted specimens for comparison, showing all the parts.

Proboscis.—The long tongue-like mouth-parts of dipterous insects are known as the proboscis, rarely as the rostrum. The labrum is rarely, if ever, absent. It is closely fused with the epipharynx to form a thin piercing blade. The labrum forms the cephalic surface of this blade and the epipharynx the caudal. This blade is known as the labrum-epipharynx. The mouth in generalized Diptera is located adjacent to the ventral margin of the head. The proboscis in such species includes only the labium. In specialized Diptera the mouth is located near the middle of the length of the proboscis and it includes the labium, a part of the maxillae, the propharynx, and the parapharynx. The mouth in such species is situated between the proximal ends of the labrum-epipharynx and the hypopharynx. The proximal end of the labrum is apparently always located distant from the ventral margin of the head. The distal opening of the pharyngaris into the cibivia is the prestomum.

Basiproboscis.—The basiproboscis, also known as the rostrum, includes the submentum, the mentum which can not be identified, the maxillae, and the oscula. It is telescopic, particularly in specialized Diptera, and is the region that has been greatly elongated. The proboscis is usually constricted near the middle of its length and the region proximad of the constriction is the basi-

proboscis. Its distal portion bears the propharynx and parapharynx in specialized Diptera.

Mediproboscis.—The cylindrical constricted area of the proboscis distad of the basiproboscis is the mediproboscis, also known as the haustellum. It is homologous with the region formed from the fused stipulae of other insects.

Distiproboscis.—The enlarged distal region of the proboscis, formed from the paraglossae and glossae, is the distiproboscis. It is also known as the oral lobes or labella.

Theca.—The large plate on the proximal portion of the caudal aspect of the mediproboscis is the theca, also known as the mentum. It is formed from the fused stipulae. The fork of the mentum is a part of the theca.

Sigma.—The distal end of the theca is frequently deeply emarginate or hollowed out and each side of the emargination is bounded by a slender projection, against which a small sclerite articulates. This small sclerite is the sigma, also known as the furca.

Kappa.—There is a small area in a few genera located laterad of each sigma. This area is the kappa. It is also known as the palpiger and its position strongly suggests such an homology. The labial palpi are always wanting in the Diptera. Some of the early anatomists and some recent writers homologize the paraglossae with the labial palpi. A study of the mouth-parts of nematocerous Diptera shows the fallacy of this view.

Pharyngaris.—The cibivia of all dipterous insects is located between the closely folded labrum-epipharynx and the hypopharynx. These two parts are together known as the pharyngaris.

Probofossa.—The cephalic aspect of the mediproboscis is deeply longitudinally furrowed. The pharyngaris, when at rest, is folded into this furrow, which is known as the probofossa, also as the labial gutter. The bottom of the probofossa is supported by three adjacent plates which usually extend throughout the length of the furrow.

Proboscella.—The mesal plate supporting the probofossa is the proboscella. It is generally continuous with the alaglossa.

Proboscaria.—The slender plate along each lateral margin of the proboscella is a proboscaria. Its distal end is usually modified and articulates against a funis. They are apparently the labellar rods of other writers.

Labellum.—The distiproboscis frequently consists of two large swollen lobes, the labella. Each is homologous with a paraglossa of other insects.

Pseudotracheae.—The caudal and distal aspects of the paraglossae or labella of many species bear numerous fine transverse dark lines, the pseudotracheae. They have been so named from their resemblance to the tracheal branches of the respiratory system. The pseudotracheae are small chitinized troughs or convex transversely striated, rarely toothed ridges. They have generally been considered as serving as conduits or gutters for the liquid food. It is more likely, since the cibivia always extends through the pharyngaris, that the primary function of the pseudotracheae is to aid the proboscis in maintaining its position upon the host while the insect is feeding. The pseudotracheae are wanting in many generalized dipterons or the ridges are greatly reduced in number.

Upsilon.—Each paraglossa in specialized Diptera is supported on the lateral aspect by a chitinized structure which is frequently Y-shaped, the upsilon. This structure has been named the furca but this name is already in use for a part of the sternal endoskeleton. The upsilons are variable in shape.

Preupsilon.—The stem of the Y of the upsilon is the preupsilon, also known as furca-1. It usually supports the cephalic surface of the dorsal part of a paraglossa and may articulate against a sigma.

Proupsilon.—One arm of the Y of the upsilon is located in or near the furrow separating a paraglossa and the mediproboscis. This is the proupsilon, also known as furca-3.

Parupsilon.—The other arm of the Y of the upsilon extends obliquely distad across the lateral surface of the mediproboscis. This is the parupsilon, also known as furca-2.

Funis.—There is a slight thickening located on the cephalic aspect and extending distad for a short distance from each lateral angle of the alaglossa and forming a bar in which the pseudotracheae terminate. This bar is the funis. It serves as a point of articulation for a proboscaria.

Paratorma.—The strongly chitinized plate, frequently triangular in outline as seen from the lateral aspect, connecting the lateral margins of the basipharynx with the tormae, is a paratorma. The tormae are usually fused into a single mesal area in those genera where the paratormae are present. The paratormae, as here defined, together with the basipharynx has been named the fulcrum. They have also been considered as a part of the tormae. The paratormae are present only in specialized Diptera.

Stipodema.—Each stipes in specialized dipterons has a part of its ental surface developed into a parademe. This parademe varies considerably in size in different genera. In some it is a long cylindrical bar. Its proximal end in such cases is free and its

distal end is articulated against the proximo-lateral angle of the labrum-epipharynx. This type of parademe is of general occurrence among the muscids and has been named the apodeme or the apodeme of the labrum. In order to distinguish it from a true apodeme and at the same time show its origin, it has been named the stipodema. This name is applicable to all sizes and stages of the parademe developed from the ental surface of the stipites whether they have the distal end attached or not.

Hyoid.—The minute sclerite located between the distal end of the basipharynx and the proximal end of the epipharynx and hypopharynx in certain specialized dipterons is the hyoid.

Falsadentes.—The mesal surface of each paraglossa adjacent to where it is fused to the alaglossa has an area of radiating thickenings or a group of tooth-like projections. These thickenings and tooth-like projections are believed to be homologous and are known as falsadentes. The area bearing these structures is known as the lamnadens or tooth-plate. The position and form of the thickenings suggest that they are solely for the support of the paraglossae. The falsadentes have been called prestomal teeth from the belief that they are closely associated in function with the pharyngaris. When the tooth-like falsadentes are present, the paraglossae are reduced in size and they are turned in such a way that the falsadentes are fully exposed and project distad as free extensions of the surface of the paraglossae. The claim has been made that the falsadentes are the primary structures used by blood-sucking Diptera in rupturing the skin. Doubt is thrown on this contention from the fact that those dipterons with the largest and most tooth-like falsadentes are not blood-suckers. The form and position of the falsadentes would suggest that their function is to give better and firmer purchase to the paraglossae and thus to support the distal end of the probofossa against which the pharyngaris is extruded.

Tabanus Sulcifrons.—The proximal end of the labium together with the proximal end of the maxillae forms a transverse area on the ventral side of the foramen for closing the caudal aspect of the head. Identify the maxillae. The submentum is membranous and telescopic. The mentum is obsolete. The proximal margin of the submentum adjacent to the foramen is a linear crescentic strongly chitinized area. The labacoriae are continuous with the proximal half of the submentum and unite it to the cardines and stipites. The short infolded constricted membranous area at the distal end of the submentum, which can be telescoped with the distal half of the submentum into the head, represents the

coria formed from the adjacent parts of the submentum and stipulae. The basiproboscis is represented by the submentum. The large structure distad of the submentum is the mediproboscis. The brownish setiferous sclerite forming the proximal part of the caudal aspect is the theca. Its proximal end is deeply roundly emarginate and the distal end bears a prominent transverse band of setae. Each disto-lateral angle of the theca is hollowed out. This hollow is in the lateral side of a long slender curved projection of the theca. There is a small crescentic sclerite located along the mesal margin of each of the curved projections. This sclerite, a sigma, is longer than the projection and extends into a slit in the theca. The proximal end of the sigma is fused to the theca. The suboval area located laterad of each sigma is a kappa. Its position is very suggestive of its homology with a palpiger. The proximal end of the kappa articulates against the hollow disto-lateral portion of the theca. Each of the large oblique swollen structures forming the disto-caudal portion of the labium is a paraglossa. They belong to the distiproboscis. The disto-caudal and mesal surface of each is crossed by numerous fine transverse ridges, the pseudotracheae. There is a distinct furrow separating the paraglossae from the mediproboscis. The lateral aspect of the mediproboscis and distiproboscis is convex and submembranous. The surface of this area bears numerous minute groups of spinulae which can be dissolved only by the use of a compound microscope. The cephalic aspect of the mediproboscis is deeply broadly furrowed. The mandibles, galeae, labrum-epipharynx, and hypopharynx, when at rest, are folded into and against this furrow, the probofossa. The mesal area of this furrow contains three adjacent plates, which extend throughout the length of the furrow. The mesal plate is the proboscella. It is continuous with a triradiate structure at its distal end, the alaglossa. The mesal projection of the alaglossa is longer than the lateral. The alaglossa is situated near the middle of the length of the paraglossae. Each lateral area of the cephalic furrow adjacent to a proboscella is a proboscaria. Its distal end is pointed and articulates against a thickening on the paraglossa, the funis. The upsilon of each paraglossa is distinct and Y-shaped. The preupsilon forms a broad brownish area on the lateral surface of the part of the paraglossa projecting caudad. A faint linear area extends proximad from the middle of its mesal margin and articulates against the distal end of a sigma. The distal end of the preupsilon is reduced and divides into a broad brownish proupsilon. This is located in the furrow separating the paraglossa and the mediproboscis. It is also divided into a curved linear parupsilon,

which extends obliquely across the lateral aspect of the mediproboscis.

Draw the lateral aspect of the labium and name all the parts.
Draw the caudal aspect of the mediproboscis and name all the parts.
Draw the cephalic aspect of the labium and name all the parts.
Draw the lateral aspect of the distiproboscis and name all the parts.

Eristalis Tenax.—The ventral side of the foramen is closed by the chitinization of the postgenae, maxillae, and labium, forming a maxaponta. The proximal half of the proboscis, the basiproboscis, is telescopic and in great part membranous. This region is formed from the maxacoriae, the labacoriae, the proximal part of the maxillae, the submentum, the oscula, and the membrane between the clypeus and labrum. The basiproboscis is greatly elongated. This elongation has been produced by the extrusion and elongation of the membranous areas associated with the mouth-appendages. It is usually retracted within the ventral margin of the head. The mouth is situated near the middle of the cephalic aspect of the basiproboscis. The small subquadrangular area located in the membrane filling the ventral emargination of the fronto-clypeus is the fused tormae. The brownish area adjacent to the ventral end of the tormae is a part of the paratormae, which are fused to the external cuticle. The mesal area of the caudal aspect of the basiproboscis is the submentum. The chitinized area on the middle of each lateral aspect of the basiproboscis to which the two blade-like structures are attached, is a maxilla. The cardo is involved in the formation of the maxaponta. The linear area located in the cuticle of the basiproboscis is the stipes. It appears to be a large area with a truncate proximal end and convex sides in cleared specimens. This entire structure, except the external brownish area, is a stipodema. The distal end of each stipes is continuous with a maxillary palpus, the long flattened setiferous lobe, and the galea, the long thin pointed sword-shaped lobe. The long brownish projection located on the meson of the cephalic aspect is the pharyngaris. The maxillary palpi and the galeae are folded against the lateral margins of the pharyngaris. The cephalic aspect of the basiproboscis proximad of the labrum-epipharynx is formed from the coria of the clypeo-labral suture and distad of the labrum-epipharynx is formed from the oscula. The theca is the large area on the caudal aspect of the mediproboscis. Its distal end is angularly emarginate. This emargination is bounded on each side by a blunt projection. The brownish thickening fused to the mesal margin of each projection is a sigma. There is only a small portion of its distal end free. The kappa of each side is obsolete. The curved brownish bar

articulating against the knob on the distal end of each sigma is a preupsilon. The mesal portion of each preupsilon is a short more strongly curved bar which articulates against the corresponding bar of the preupsilon of the other side. The proupsilon is usually obsolete. There is in some specimens a thinner portion at the distal end of the preupsilon, apparently a continuation of it, which is considered as the proupsilon. The short transverse brownish bar on the lateral aspect near the distal end of the preupsilon is the parupsilon. It is not connected with either the preupsilon or the proupsilon. The paraglossae are swollen. They have distinct pseudotracheae on the distal and mesal aspects. The proboscariae are distinct brownish cords. The proximal end of each is curved and the distal end articulates against a large prominent projection on a funis. Each funis mesad of this articulation is extended as a pointed projection and articulates against the distal end of the fused proboscella and alaglossa. The proboscella does not extend as far proximad as the proboscariae and is continuous at its distal end with the alaglossa, which is represented by the bluntly rounded free end. The funis is finely transversely striated like the pseudotracheae. The surface of the mediproboscis between the proboscella and proboscariae and laterad of each proboscaria is more strongly chitinized than elsewhere. The caudal aspect of the basiproboscis should be removed so as to expose the propharynx and parapharynx. The caudal aspect of the basipharynx is convex with a thickening on the meson and another along each lateral margin. A paratorma extends cephalad and dorsad from each lateral thickening and fuses with the paratorma of the other side adjacent to the tormae and also with the external cuticle, showing as an elongate sclerite, which articulates against the ventral margin of the tormae. Each lateral margin of the cephalic end of the basipharynx is produced into a broad flat bluntly rounded cornua. There is attached to the caudal side of the subglobular cephalic end of the basipharynx a membranous postpharynx. It is swollen, but not modified into an antlia. The ventral portion of the basipharynx is gradually reduced in size. The labrum-epipharynx and hypopharynx are united to its distal end within the lumen of the basiproboscis. The minute membranous area located on the caudal aspect at the distal end of the basipharynx and sometimes more or less concealed by the proximal end of the labrum-epipharynx is the hyoid. The condyles on the labrum-epipharynx articulate against the basipharynx. The lateral margins of the labrum-epipharynx and hypopharynx are fused where they pass through the external cuticle of the basipharynx. This is the location of the mouth. The labrum-epi-

pharynx is a long thin broad convex-concave projection. Its distal end is transverse with six long slender teeth. It can be extended beyond the alaglossa. The hypopharynx is a long slender flat projection, as long as the labrum-epipharynx, which fits closely against its concave caudal aspect. The salivary duct passes through the lumen of the basiproboscis caudad of the basipharynx and is attached to the hypopharynx a short distance from its proximal end. The salatuba is wanting. The salivos is located at the distal end of the hypopharynx.

Draw the lateral aspect of the proboscis and name all the parts.
Draw the cephalic aspect of the proboscis and name all the parts.
Draw the caudal aspect of the proboscis and name all the parts.
Draw the lateral aspect of the prepharynx and name all the parts.

Calliphora Viridescens.—The ventral side of the foramen is closed by a maxaponta. The proximal half of the proboscis, the basiproboscis, is swollen and funnel-shaped. There is a distinct constriction separating this region from the mediproboscis. The caudal and lateral aspects are formed from the labacoriae, maxacoriae, the submentum, and a part of the maxillae. The dorsal aspect is formed from the extension of the clypeo-labral suture and the remainder of the maxillae. The labrum-epipharynx is attached externally to the distal end of the basiproboscis. The tormae are represented by two subquadrangular adjacent areas located in the membrane ventrad of the fronto-clypeus. Their dorso-lateral angles are prolonged. The inverted V-shaped area attached to the ventral margin of the tormae is the fused external part of the paratormae. There is a long porrect setiferous one-segmented maxillary palpus attached near the ventral end of each arm of a paratorma. The stipes is represented on each side by an area which extends laterad for a short distance from the proximal end of each maxillary palpus. Its surface bears long setae. There is another similar area extends distad from each maxillary palpus as a suboval area. Its surface is covered with short setae and each is a secondary sclerite. The caudal aspect of the mediproboscis is covered by the theca. It is broadest at the proximal end and its surface is sparsely setiferous. The distal end of the theca is emarginate. The sides of the emargination are bounded by bluntly rounded projections. The small sclerite articulating against the distal end of each of these projections is a sigma. The kappa of each side is obsolete. Each sigma projects disto-laterad and serves as a point of articulation for the upsilon of one side. The upsilons are located in the furrow separating the mediproboscis and distiproboscis. The portion articulating against the sigma is a preupsilon. The mesal end of

each preupsilon is continued until it fuses with the preupsilon of the other side forming the so-called axial apophysis. The sigma articulates in a distinct acetabulum. The portion of each upsilon distad of the acetabulum belongs to a proupsilon. The parupsilon is obsolete. The probofossa is deep. The proboscella forms the bottom and sides of this furrow. The linear thickenings forming the cephalic margins of the proboscella are the proboscariae. They are more strongly chitinized than the latter and their distal ends articulate against the funes. They are strongly chitinized plates and serve to keep the mesal surfaces of the paraglossae adjacent. The mesal ends of the funes are fused with the alaglossa, which is continuous with the distal end of the proboscella, forming a small mesal projection. The distal end of the labrum-epipharynx is held in place by insertion between the funes. The paraglossae are small swollen lobes with prominent pseudotracheae on their distal and mesal aspects. The lateral surface of each paraglossa adjacent to the lateral ends of the pseudotracheae bears numerous long setae. The basipharynx is a convex tube on the caudal aspect with mesal and inconspicuous lateral thickenings. The proximal end is modified into a long cornua, between which the membranous postpharynx is attached. A paratorma extends cephalad and dorsad from the thickening on each lateral margin of the basipharynx, and fuses on the meson adjacent to the tormae with the paratormae of the other side and the cuticle of the external surface to form the exposed inverted V-shaped part of the paratormae. The small quadrangular lighter colored area at the distal end of the basipharynx is the hyoid, against which the labrum-epipharynx and hypopharynx articulate. The labrum-epipharynx is convex on the cephalic aspect and much broader on the proximal portion. There is a deep furrow on the caudal aspect over which the hypopharynx fits. The labrum-epipharynx is longer than the hypopharynx and tridentate at the distal end. The proximal end of the labrum-epipharynx is abruptly narrowed where it extends through the cuticle to the hyoid. The salivary duct is attached to the proximal end of the hypopharynx and extends through the hypopharynx to its distal end, where the salivos is located. The salatuba is wanting. The long cylindrical bar located in the lumen of the basiproboscis on each side of the basipharynx is a stipodema. Its proximal end is swollen and the distal end is curved and articulates against the abruptly narrowed latero-proximal portion of the labrum-epipharynx.

Draw the lateral aspect of the proboscis and name all the parts.
Draw the cephalic aspect of the proboscis and name all the parts.
Draw the caudal aspect of the proboscis and name all the parts.
Draw the lateral aspect of the prepharynx and name all the parts.

CHAPTER IV

THORAX

The second region of the body is the thorax. It is divided into three segments or subregions. These are the prothorax, which bears the first pair of legs or the prolegs; the mesothorax, which bears the second pair of legs or mesolegs and the first pair of wings or the mesowings; and the metathorax, which bears the third pair of legs or metalegs and the second pair of wings or metawings.

The thoracic segments are frequently considered as typical segments. Each consists of a distinct tergum, two pleura, and a sternum. A leg is attached in the coria between a pleuron and the sternum and is articulated against a process on the pleuron. A wing is attached in the coria between a pleuron and the tergum and is articulated against processes on the pleuron and the tergum.

The tergum, pleura, and sternum of each thoracic segment have been considered by some authors as consisting typically of two similar adjacent transverse sclerites. For this reason these authors believed that each thoracic segment had been formed by the fusion of two segments. The cephalic transverse row of sclerites represented one segment and the caudal row the other. Other evidence was the apparent division of the proximal segment of each leg, the coxa, into a caudal and a cephalic portion. This view was also supported by the fact that each pair of neuromeres of the ventral cord is connected by two transverse commissures during embryonic development. These commissures fuse during late embryonic life so that each segment contains only the typical number of neuromeres.

The head is joined to the thorax by a broad area of membrane commonly designated as the neck, cervicum, veracervix, microthorax, or cervix. This membrane in most insects contains definite chitinized areas, which are known as the cervical or juglar sclerites. These sclerites may occur on one or on all four of the sides of the neck and are considered as the tergal, pleural, and sternal sclerites of the neck. The labium, which is loosely united with the head in generalized insects and firmly fused with it in specialized insects, is considered as the appendage of the neck. These sclerites represent, therefore, the segmental part of the labial segment. The neck, exclusive of its appendages, is designated as the cervix. The cervical sclerites have been considered by some writers as homodynamous with the sclerites situated in the mesocoria and metacoria.

These sclerites have been called the intersegmentalia but the proof that such a relationship exists or that it does not exist, is extremely slight.

The sclerites of the cervix, except in certain generalized insects, are limited to two in each pleuron. The cephalic sclerites articulate against the odontoideae and are the points upon which the head rotates. In those insects where the head is deeply retracted into the cephalic end of the prothorax, all the sclerites may be obsolete and the cervix entirely membranous or the sclerites may be large and well developed. The tergal and sternal sclerites, when present, are usually small, disconnected, and not strongly chitinized. The pleural and sternal sclerites are closely associated with the labium in generalized insects and with the prothorax in specialized insects. The parts of the cervix have been described with the parts of the thorax. This is not because they are considered more closely related to the thorax, but simply because they are more convenient to study in connection with the thorax.

The tergum of a thoracic segment contains a mesal depression or elevated line, the median suture. This suture is continuous with the epicranial stem and marks the line of closure of the embryo and the line of rupture of the cuticle when it is moulted. The sternum is also at times marked by a mesal depression or ridge, the neural groove, the ventro-median suture, or the neural suture, which probably marks the position of the neural groove of the embryo. In the sternum of certain generalized insects, a more striking structure is preserved. Embryologists have called attention to the fact that the general disk of each segment at a comparatively early embryonic stage consists of three parts, a median field and two lateral fields. The legs are developed as evaginations of the lateral fields. The sternum of an insect consists, therefore, of three parts. The portion derived from the median field is considered as the sternannum and sternellum. The portion derived from the part of each lateral field located between a leg and the media field is considered as a sternoidea and trochantin. The portion laterad of each leg gives rise to the pleuron and the adjacent one-half of the tergum.

The term tergum is used for the entire dorsal aspect of each segment of the body. In the following pages, however, the term notum, which is generally used by systematists, has been employed for the dorsum of the thoracic segments. The notum is separated from the pleuron on each side by a longitudinal coria, the notacoria. This coria is sometimes reduced to a suture and is then known as the notasuture. In the mesothorax of certain insects the

cephalic portion is a suture, the notasuture, and the caudal portion a coria, the notacoria. In the wing-bearing segments the notacoria is continuous with the dorsal and ventral cuticle of the wing and contains several small sclerites between the notum and the wing and between the pleuron and the wing. The portion of the notacoria containing sclerites is the rotaxis, the portion continuous with the dorsal side of the wing is the notarotaxis and that continuous with the ventral side is the pleurotaxis.

The coria separating each lateral field (Fig. 9, *stc*) of the sternum, a sternoidea and a trochantin, from a pleuron, is the sternacoria. It is usually reduced to a suture (Fig. 9, *sts*) and is then known as the sternasuture. There is also a coria separating each lateral field from the median field (Fig. 9, *tcc*), the trocoria. It is also usually reduced (Fig. 9, *tcs*) to a suture, the trocasuture. The proximal end of each leg is always attached to the sternum and the pleuron by an area of cuticular membrane, the coxacoria. Each sternoidea in generalized insects consists of two sclerites, the presternoidea and the parasternoidea. Each trochantin also consists of two sclerites, the pretrochantin and the paratrochantin. Where the sclerites of the sternoidea or of the trochantin are fused, which is the usual condition, they are designated simply as the sternoidea or as the trochantin. The sclerites derived from a lateral field have lost their primitive form in most insects. The two sclerites of the trochantin are fused, greatly reduced in size, and located in the coxacoria. Their association with the proximal end of the leg is so close that they have been considered as an integral part of the leg by most writers. The two sclerites of the sternoidea are fused and greatly reduced in size, but vary somewhat in their associations. In the prothorax they are closely articulated with the cervapleuron and, when present, are located along the cephalic margin of the prosternum or propleuron. The caudal migration of the trochantin and the cephalic migration of the sternoidea in the prothorax has resulted in the union of the prosternacoria and protrocoria (Fig. 9, *ttc*) into a single coria, the totacoria. This coria is usually represented by a suture, the totasuture, which separates the proepisternum, a sclerite of the pleuron, and the prosternannum. In the mesothorax and metathorax the sternoidea always retains its position between the episternum and the sternannum. It is sometimes a small quadrangular sclerite with a distinct sternasuture and trocasuture. In most insects the sternasuture is obsolete and the episternum and sternoidea are fused. The trocasuture is more frequently present, but in the great majority of insects the sternasuture and trocasuture are both obsolete and there is a continuous

undivided area extending between the articulations of the two wings. The episterna and epimera are divided in a few orders by longitudinal furrows which have been incorrectly identified as the equivalent of sternasutures. The position of these furrows alone, even if they did not originate from the cephalic margin of the sclerites in some cases and from the caudal margin in others, even in the same order, precludes their being considered as sternasutures.

Authors are agreed in considering that the sternum of generalized insects consists of at least two distinct areas, the cephalic the sternum and the caudal the sternellum. They also designate the entire ventral aspect of a thoracic segment as the sternum. This latter term, because it has been much longer in use, has been retained here for the entire ventral aspect of a segment. The term sternellum has been retained for the caudal portion and the cephalic portion has been designated as the sternannum. The sternellum is usually smaller than the sternannum and is frequently greatly reduced and sometimes entirely membranous. The sternum of authors is in most cases, therefore, the same as the sternannum. The caudal extent of the sternannum, even if the suture between the sternannum and sternellum is obsolete, which is generally the case, is indicated by the points of invagination of the furcae, a part of the entosternum or endoskeleton. The two main sclerites of each pleuron are likewise differentiated by the point of invagination of the entopleuron, also a part of the endoskeleton. This invagination, the pleuradema, is usually associated with the ventral portion of the suture separating these sclerites.

The students of the different orders of insects and of the anatomy of insects have applied various names to the parts of the thorax. Some of these are indicated under the descriptions, no attempt has been made to make the list complete. The shape of the sclerites and the position of the sutures can be best determined from specimens cleaned and cleared in caustic potash. The specimens should be studied in seventy per cent alcohol in Syracuse watch-glasses.

Sternum.—The ventral aspect of the thorax is the sternum. It comprises several sclerites in generalized insects like the cockroach, but only a few in most insects. There is, where such a reduction occurs, a corresponding narrowing of the sternal sclerites. The sternum is a narrow mesal area limited only at its cephalic and caudal ends. The sternacoriae or sternasutures are generally obsolete. The ventral aspect of the mesothorax, which is generally much larger than the prosternum or metasternum, is sometimes known as the pectus. The number of sternal sclerites in a few cases is ap-

parently larger than the typical number. The primary sclerites in such insects are subdivided by folds that have lost their chitinization and appear as sutures. This is particularly true among plecopterous insects, where these subdivisions have been considered by some as primary sclerites.

Coxacoria.—The membrane extending between the proximal segment of the leg, the coxa, and the sternum and the pleuron (Fig. 9, *cxc*) is the coxacoria. It is bounded on the lateral margin by the pleuron and on the cephalic, mesal, and caudal margins by the sternum.

Coxafossa.—The opening (Fig. 9, *cxf*) left in the ventral aspect after the removal of the proximal segment of the leg. the coxa, is the coxafossa. Each is an artifact and is usually circular or transverse oval in outline.

Coxacava.—The portions of the sternum and pleuron adjacent to a coxafossa are frequently deeply infolded and form a depression

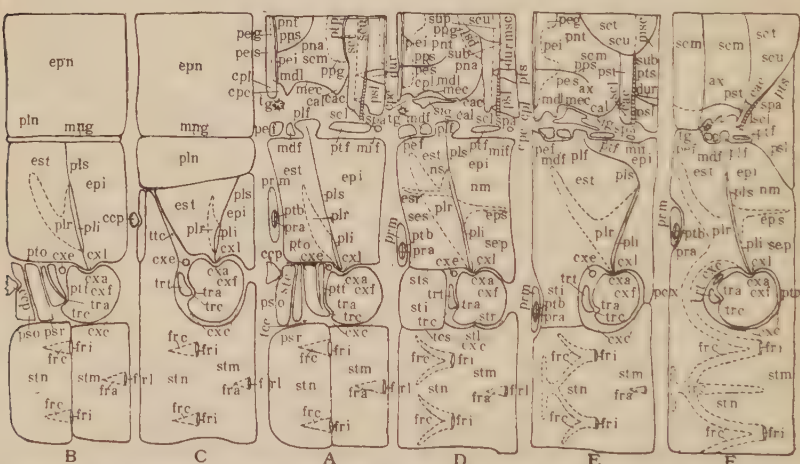

Fig. 9.—Hypothetical thoracic segments. A, type; B-C, prothorax; D-F, mesothorax and metathorax.

in which the proximal one-half or more of the coxa is concealed. This is a coxacava, also known as a coxal cavity. The coxafossa and coxacoria are located at the bottom of the coxacava.

Sternannum.—The cephalic part of the mesal portion of the sternum (Fig. 9, *stn*) is the sternannum. It is derived from the median field and in generalized insects is limited to a small mesal area. The sternal sclerites derived from a lateral field in most insects are either greatly reduced in size or fused with the pleuron. The sternannum is enlarged in such cases and extends to the pleura and forms the cephalic and the greater part of the mesal boundaries

of the coxacoriae. The cephalic end of the sternannum has been considered as a distinct sclerite, the praesternum, also known as the presternite, prebasisternite, sternal laterale, or antesternum. The sternannum is generally designated by systematists and writers as the sternum. It also comprises the regions designated as the basisternite, laterosternite, and furcasternite.

Sternellum.—The caudal part of the mesal portion of the sternum (Fig. 9, *stm*) is the sternellum or poststernum. It is usually smaller than the sternannum and limited to the region between and caudad of the coxacoriae. In generalized insects the sternellum is not well chitinized and in most insects it is fused with the sternannum without any indication of a suture. It is frequently concealed by the close apposition of the adjacent sternanna. The portion located caudad of each coxacoria is frequently fused with an epimeron. The sternellum includes the regions designated as the postfurcasternite and spinasternite.

Entosternum.—The cuticular arms that extend into the body-cavity from the sternum are known as the entosternum. They are derived from invaginations which appear during embryonic development and are marked externally in the adult by pits or thickenings. The parts of the entosternum are also known as the apophyses or ventral apodemes.

Furca.—The two arms derived from the invaginations located between the sternannum and sternellum (Fig. 9, *frc*) are the furcae. They mark the division between these sclerites when the suture is obsolete. The two furcae are usually fused adjacent to the body-wall, but soon separate and extend dorsad and cephalad. Each furca is frequently subdivided into two or more branches and is often connected or fused with the entopleuron. The furcae are the most important parts of the entosternum and are rarely, if ever, wanting. They are also known as the entosternum, entothorax, antefurca, medifurca, postfurca, episterne, or apophysen.

Furcina.—The pit or thickening on the ectal surface of the sternum (Fig. 9, *fri*), marking the place of invagination of a furca, is a furcina.

Furcella.—The arm derived from an invagination located on the meson of the caudal portion of the sternellum (Fig. 9, *fra*) is the furcella. It is usually a slight projection and is generally wanting, particularly in the mesothorax and metathorax. It is also known as the spina or monapophysis.

Furcellina.—The pit or thickening on the ectal surface of the sternellum marking the place of invagination (Fig. 9, *frl*) of the furcella is a furcellina.

Trochantin.—There is in a few families of generalized insects a group of two narrow sclerites located cephalad of each coxacoria, a trochantin. The cephalic sclerite (Fig. 9, *pto*) is the pretrochantin, also known as the antecoxal piece, the first antecoxal piece, or antecoxal trochantin. The caudal sclerite (Fig. 9, *ptt*) is the paratrochantin, also known as the trochantin or coxal trochantin. The lateral end of the paratrochantin articulates against the episternum, a sclerite of the pleuron, or rarely is fused with it. These sclerites are a part of the sternum and are derived from a lateral field. In most insects they are fused (Fig. 9, *trt*) into a single sclerite, greatly reduced in size, and are designated as the trochantin or a part as the accessory trochantinal plate. The trochantin is located in the coxacoria and is closely associated with the proximal segment of the leg, the coxa. It has frequently been described as a sclerite of the leg. The trochantin is rarely wanting, but is frequently concealed in the bottom of a coxacava.

Trocacoila.—The mesal end of the trochantin (Fig. 9, *trc*) is modified into a condyle, the trocacoila, which articulates in an acetabulum in the cephalic margin of the coxa, the trocartis. The trocacoila is formed by a fusion of the mesal ends of the protrochantin and paratrochantin.

Sternoidea.—There is in a few families of generalized insects a group of two narrow transverse sclerites located cephalad of each pretrochantin, usually larger than the sclerites of the trochantin, the sternoidea. The cephalic sclerite (Fig. 9, *pso*) is the presternoidea, also known as the second antecoxal piece, the episternal lateral, or the precoxale. The caudal sclerite (Fig. 9, *psr*) is the parasternoidea, also known as the sternal laterale. The sternoideae and trochantins represent the portions of the sternum derived from the lateral fields. In the mesothorax and metathorax the presternoidea and parasternoidea are fused and frequently are combined with the sternannum and episternum, forming a continuous area without any indication of sutures. It is, therefore, impossible to recognize the sternoideae in such cases and they are disregarded in the nomenclature of these parts. In the prothorax the sternannum and episternum are prolonged between the sternoidea and trochantin until they fuse. The sternoidea, when present, is represented by a small sclerite along the cephalic margin of this fused area. It can be recognized from its articulation with a cervepimeron (Fig. 9, *cep*). When apparently wanting, the sternoidea is considered as fused to the cephalic margin of the fused episternum and sternannum.

Coxella.—The minute sclerite located in the coxacoria near

the lateral end of the cephalic margin of the coxa (Fig. 9, *cxc*) is the coxella. The ental surface is sometimes prolonged as a parademe. It is also known as the accessory or complimentary coxal plate or the juxtacoxale.

Coxata.—The minute sclerite located in the coxacoria on the caudal side of the coxa is the coxata. It is present in only a few insects.

Coxola.—The minute sclerite located in the coxacoria at the lateral end of the coxa is the coxola. It is only rarely present.

Sternartis.—The primary articulation of the proximal end of each coxa with the thorax is located upon the lateral margin of the coxa (Fig. 9, *cxa*), the coxartis. There is present in certain insects a blunt spine-like projection of the sternellum adjacent to the coxa which serves as a secondary point of articulation. This projection (Fig. 9, *stl*) is a sternacoila. It articulates firmly in a sternartis (Fig. 9, *str*) in the coxa. The sternacoila is usually located at the mesal end of the coxacoria, but may be located near the middle of its cephalic or caudal margin. They are rarely present on the prosternum and are sometimes limited to the metasternum.

Sternal Processes.—The mesal part of the sternum, particularly in the Coleoptera, extends either cephalad or cauded as a projection between the coxacavae or coxacoriae. The projections formed at the cephalic end of the sterna are known as the coxal processes and those formed at the caudal end as the sternal processes.

Pleuron.—Each lateral aspect of a thoracic segment is a pleuron. The sternacoria or sternasuture and trocacoria or trocasuture are frequently obsolete and the pleuron and sternum form a continuous area. The pleuron is frequently very narrow in the prothorax, due to the extension of the pronotum onto the lateral aspect and the notasuture is frequently obsolete. The notacoria is usually a distinct broad area in the mesothorax and metathorax. The sternacoria (Fig. 9, *stc*) or sternasuture (Fig. 9, *sts*) and trocacoria (Fig. 9, *tcc*) or trocasuture (Fig. 9, *tcs*) are replaced in the prothorax by the totasuture (Fig. 9, *ttc*).

Episternum.—The transverse cephalic sclerite (Fig. 9, *est*) of the pleuron of each thoracic segment is the episternum. It is usually the largest sclerite of the pleuron and its cephalo-dorsal portion is associated with the notum and its cephalo-ventral portion with the sternannum. The episternum of the mesothorax and metathorax of most insects, as already noted, is a compound of the episternum and sternoidea, also known as the antepleuron, coxopleure. A cephalic portion of the episternum is sometimes modified and

named the preepisternum, katapleure, or episternal lateral. The sternoideae are sometimes named the preepisterna.

Epimeron.—The transverse area located along the caudal margin of the episternum (Fig. 9, *epi*) is the epimeron. It is usually a sclerite of some size, but may be reduced to a narrow band, and is also known as the epimerum, postpleuron; or anopleure. The infolded lateral portion of the epimeron in the Coleoptera is the supra-epimeron or postparapterum.

Pleural Suture.—The suture (Fig. 9, *pls*) separating the episternum and epimeron of each thoracic segment is the pleural suture. It is frequently represented by a furrow, sometimes of considerable depth, the pleural furrow.

Coxacoila.—The caudo-mesal or the caudo-ventral angle of the episternum is produced (Fig. 9, *cxl*) into a condylar process, the coxacoila. It articulates in a distinct acetabulum, the coxartis, in the proximal segment of the leg, the coxa. This is the primary articulation of the leg and is always present. The coxacoila projects under the coxa and is frequently concealed unless the coxa is removed. In generalized insects the coxacoila is derived from the episternúm, but in many insects it is a combination of the episternum and epimeron and is usually closely associated with the pleuradema.

Precoxalia.—The adjacent parts of the sternannum and episternum are usually fused, forming a continuous area (Fig. 9, *pcx*) cephalad of the coxacoria, the precoxalia. It is also known as the precoxale.

Postcoxalia.—The adjacent parts of the sternellum and epimeron are frequently fused, forming a continuous area (Fig. 9, *ptx*) caudad of the coxacoria, the postcoxalia. It is also known as the postcoxale.

Entopleuron.—The cuticular arm that extends into the body-cavity from each pleuron is known as the entopleuron. It is derived from an invagination which appears during embryonic development. Each is also known as a lateral apodeme, apodema, a pleural ridge, or a pleural arm.

Pleuradema.—The arm or lamella derived from the invagination (Fig. 9, *plr*) of the entopleuron is a pleuradema. It varies considerable in extent, from a small lamella along the ental surface of the pleural suture to a large arm which is fused with the entosternum. The pleuradema is usually fused to the ental surface of the coxacoila.

Pleurademina.—The point of invagination of the pleuradema is frequently marked on the ectal surface (Fig. 9, *pli*) as a pit or

thickening, the pleurademina. It is always associated with the pleural suture and is generally located near its ventral end. The exact point of invagination is often concealed by the fusion and thickening of the adjacent parts of the episternum and epimeron.

Notum.—The dorsal aspect of a thoracic segment is the notum, also known as a tergum. It extends onto the lateral aspect in the prothorax and limits the extent of the pleura. The primary sutures are obsolete in this segment and the notum forms a single undivided piece. In the mesothorax and metathorax the notum is limited to the dorsal aspect in the adult and is divided into four primary sclerites or regions in generalized insects. This region has been divided into two regions by several authors. The cephalic region, comprising the three cephalic sclerites, is known by these authors as the notum or scutoscutellum and the caudal region, comprising the fourth sclerite, is known as the postnotum, the pseudonotum, or the postscutellum.

1. CERVIX

The cervix in many insects is wholly or in great part concealed by the close apposition of the head and prothorax. It finds its greatest development in those insects where the prothorax has been greatly elongated and the prolegs are fitted for grasping, but is usually distinct in generalized insects. The modification in its form is undoubtedly due to the change in the shape of the head which is correlated with the form and function of the mouth-parts. When sclerites are covered or telescoped, there is a tendency for them to lose their chitinization. It is not strange, therefore, since the cervix is usually retracted within the cephalic end of the prothorax, that it should frequently be entirely membranous. This does not hold good, however, with many coleopterous insects, where the maximum amount of contraction is found.

The dorsal portion of the cervix is known as the cervanotum, the ventral portion as the cervasternum, and each lateral portion as the cervapleuron. The cervanotum is more often membranous than otherwise. Each cervapleuron frequently contains two sclerites, placed end to end, of which the cephalic sclerite is the cervepisternum and the caudal the cervepimeron. The cervasternum may contain one or two chitinized areas, if two, the cephalic sclerite is the cervasternannum and the caudal the cervasternellum. The cervacoria and procoria, because of the general membranous condition of the cervix, can only be identified with certainty adjacent to the foramen and labium and adjacent to the prothorax.

The sclerite of each cervapleuron are also known as the jugular

sclerites or pieces jugularies while the sclerites of the cervix were named collectively by Huxley as the cervical sclerites and by Newport as the prothoracic paraptera. Crampton considers the cervical sclerites as homodynamous with the sclerites which he identifies in the mesocoria and metacoria and which he names the intersegmentalia or intersegmental plates. The cervical sclerites are here considered as the sclerites of the labial segment, while the so-called intersegmentalia of the other segments are considered as parts of the sterna and as peritremes.

Blatta Orientalis.—The cervix of this species, as well as that of other species of this family, shows the most primitive condition of this region found among insects. It is strongly depressed, long and broad, and contains several distinct chitinized areas, which are broadly surrounded by coria. The sclerites should be identified on untreated specimens. The cervanotum, located on the dorsal aspect, is membranous for the most part, the chitinized part is a mesal area, the cephalic end of which is pointed and continuous with the dorso-meson of the occiput. There is a transverse constriction near the middle, dividing the chitinized portion into two parts. The cephalic part is diamond-shaped. Each lateral margin is broadly dilated on the cephalic fourth. The cephalic end of the caudal part is convex, the caudal end is transverse and gradually merges with the membrane. The cervapleura are located on the ventral aspect and each cervapleuron contains two large sclerites, a cervepisternum and a cervepimeron. The large brownish cephalic sclerite located on each lateral margin of the ventral aspect is a cervepisternum. It extends longitudinally and its cephalic end is pointed and articulates in an acetabulum in the caudal margin of a maxillaria. The lateral portion is setiferous and infolded, forming an irregular swelling. There is a broad area of spinulae extending along the bottom of this infolded area and connected with a band extending along the lateral margin of the cephalic half of the cervanotum. The caudal transverse subquadrangular sclerite, articulating against the caudal margin of each cervepisternum, is a cervepimeron. The mesal ends are almost adjacent. Each cervepimeron is folded on a line with the lateral margin of the cervepisternum and each consists of an exposed ventral surface and a concealed dorsal surface. The caudal end of the dorsal surface is pointed and articulates against a propresternoidea. The faint transverse fold extending across the meson and between the cervepimeron and propresternoideae to the dorsal aspect is the procoria. The cervasternum consists of two transverse distant parallel crescentic chitinized bands. They are located on the ventral aspect

between the cervepisterna. The cephalic band represents the cervasternannum and the caudal the cervasternellum. The remainder of the cervasternum is membranous.

Draw the dorsal aspect of the cervix and name all the parts.
Draw the ventral aspect of the cervix and name all the parts.

Melanoplus Differentialis.—The head fits closely against the prothorax and conceals the cervix. The head should be pulled away from the prothorax, being careful not to tear the coria, so as to expose the parts of the cervix. The cervanotum is entirely membranous. Each cervapleuron is membranous, except for two small sclerites arranged in the form of a V and forming its ventral boundary. The cephalic half of the V is the cervepisternum. Its ventral margin is uniformly convex and its dorsal margin is irregular. The cephalic end is rounded and articulates against a maxillaria. The sclerite extending from the caudal margin of the cervepisternum to the prothorax is the cervepimeron. Its dorsal and ventral margins are convex. The cephalic end is truncate. Each cervapleuron contains three parademes. The largest one is located at the caudo-dorsal angle of the cervepisternum. This parademe is sometimes homologized as a cervapleuradema. Its position precludes such an homology. There is a small parademe located near the cephalic end of the dorsal margin of the cervepisternum and the third is located on the dorsal part of the cervapleuron near the foramen. The cervasternum consists of coria for the most part. The cephalic portion is not so strongly chitinized as the caudal, which is smooth and contains a small round mesal area and a much larger area on each lateral third.

Draw the lateral aspect of the cervix and name all the parts.

Hydrous Triangularis.—The head is retracted into the prothorax and the cervix concealed. The cervix is depressed, the cervanotum is confined to the dorsal aspect. The meson of the cephalic portion contains a glabrous strongly chitinized area. There is on the caudal half on each side of the meson a transverse more strongly chitinized bar bearing numerous chalazae. The sclerites of the cervapleura are distinct brownish areas. Each long strap-like area is a cervepimeron. The caudal portion is L-shaped and folded against the bar-like portion. The surface of the L-shaped portion articulates against the cephalic margin of the prosternannum. The cephalic end of the cervepimeron is blunt and there is a minute circular cervepisternum located between the cervepimeron and the head. The cervasternum is membranous. It may contain some transverse thickened folds bearing chalazae.

Draw the ventral aspect of the cervix and name all the parts.

Corydalus Cornutus.—The cervix in the larvae of this species is complicated. It is depressed, consists of a dorsal and a ventral aspect and a very narrow lateral aspect. The cervasternum occupies the ventral aspect. The four-sided sclerite at the caudal end of the gula, the sternellum of the gula of some writers, is the cervasternannum. The cervasternellum is the large transverse band caudad of the cervasternannum. The lateral ends extend onto the dorsal aspect. The cervepisternum and the cervepimeron are considered as wanting, if present, they are indistinguishably fused with the cervasternellum. The cervanotum is a long broad area. The caudal portion is transversely infolded, the fold resting upon the pronotum. The cephalic portion is also infolded, the fold resting upon the occiput. There is a transverse sclerite located in the bottom of this fold, each lateral end a conical projection which supports a lateral end of the cervasternellum.

Draw the ventral aspect of the cervix and name all the parts.
Draw the dorsal aspect of the cervix and name all the parts.

Tabanus Sulcifrons.—The caudal aspect of the head is broadly concave and conceals the cervix. Make a preparation by removing a'l of the head except a narrow area about the foramen and cutting obliquely through the cephalic part of the mesothorax. The cervix is short, its sclerites are well developed, and closely associated with those of the prothorax. The cervanotum is membranous. The sclerites of the cervapleura are located on the ventral part of each lateral aspect. The minute blackish subquadrangular cephalic area of each cervapleuron is a cervepisternum. Its cephalic end is pointed and articulates against an odontoidea, to which it usually remains attached when the head and thorax are separated. The cervepisternum is more or less concealed by a fold of membrane. Its caudal end is oblique and is overlapped by the larger sclerite caudad of it, the cervepimeron. It consists of two parts, a minute cephalic blackish portion and a much larger caudal brownish mound-shaped portion. The cephalic portion, subequal in size to the cervepisternum, is bluntly rounded. The oblique caudal end of the cervepisternum articulates against the dorsal side of the cephalic portion of the cervepimeron. The caudal mound-shaped portion of the cervepimeron is triangular and its surface is setiferous. Its ental surface is covered in great part by a thin parademe produced from its lateral and caudal margins. The ental surface of the cephalic half of the dorsal surface is produced as a lamellate parademe. The ental surface of the caudal end of the cervepisternum, which is produced as a parademe, articulates against this lamellate parademe of the cervepimeron. The cephalic part of the cerva-

sternum is membranous, the caudal part contains three chitinized areas. The most distinct is the convex mesal setiferous area located between the caudal ends of the cervepimera, divided by a constriction into two parts, a blackish cephalic portion and a lighter colored caudal portion. The second and third areas are lateral in position. Each is the small convex subtriangular area located between the mesal setiferous area and the mesal margin of a cervepimeron.

Draw the cephalic aspect of the cervix and name all the parts.

Libellula Pulchella.—The cervix is concealed by the concavity in the caudal aspect of the head. The sclerites of the cervix are comparatively large and aid in the rotation of the head. Specimens with the head removed and in place should be examined. The cervanotum is membranous except a transverse line of cuticle near the middle of its length connecting the large sclerites of the cervapleura. The sclerites of each cervapleuron are strongly chitinized and distinct. The large sclerite of each cervapleuron is a cervepimeron. The ventral portion is a large semicircular area. Its ventral margin is convex with a convex dilation near its middle. A slender band of cuticle extends dorso-cephalad from its caudal end for a short distance to a whitish or brownish bell-shaped thickening which is also a part of the cervepimeron. The ental surface of the cephalic end of each semicircular portion is produced into a quadrangular plate or parademe. The cephalic parts of this plate extends dorsad within the body-cavity for a short distance and then bends at a right angle. It then extends cephalo-mesad and adjacent to the corpotentorium fuses with the parademe from the cervepimeron of the other side. This fused structure articulates tightly in an acetabulum in the middle of the corpotentorium. The surface of each parademe, where it bends at a right angle, is roughened for the attachment of muscles. The slender brown club-shaped sclerite, largest at its caudal end, located in the membrane cephalad of each cervepimeron, is a cervepisternum. Its cephalic end articulates against an odontoidea and its caudal end against the cephalic end of a cervepimeron. The cervasternum is membranous except for a minute crescentic chitinized area on each side of the meson near the labium.

Draw the ventral aspect of the cervix and name all the parts.
Draw the sinistral aspect of the cervix and name all the parts.

2. PROTHORAX

The prothorax is readily identified from the fact that it bears the first pair of legs. It is always a distinct region in generalized insects, but is greatly reduced in most specialized insects. In some

it is closely associated with the cervix and the two are fused with the mesothorax, so that from a cursory examination, it is difficult to decide the segmental position of some of the sclerites. The notum of the prothorax always consists of a single sclerite and is sometimes crossed by suture-like furrows. It is a narrow transverse area closely articulated to the mesonotum in the Hymenoptera and known as the collar.

The thorax of specialized insects represents two very distinct types of arrangement of sclerites. One of these is found in the prothorax and the other in the mesothorax and metathorax. The most generalized condition is found among pterygote insects in the family Blattidae, where the parts of the three thoracic segments, at least as far as their pleura and sterna are concerned, are practically identical. There soon appears, however, a striking modification. In the prothorax of other insects the trochantins are found distant from their position between the sternannum and episternum, greatly reduced in size, and associated with the procoxae. The sternoideae are also found distant from their normal position adjacent to the trochantins and fused with the cephalic margin of the sternannum and episternum. Through this migration the sternacoria and trocacoria of each side are combined, forming a single area, the totacoria, which through specialization is usually modified into a suture, the totasuture, separating the sternannum and episternum.

Epinotum.—The dorsal aspect of the pronotum (Fig. 9, *epn*) is the epinotum. It is usually a large broad area in generalized insects.

Pleuranotum.—The pronotum forms an area (Fig. 9, *pln*) of varying size, usually a narrow longitudinal area along each lateral aspect, the pleuranotum.

Marganotum.—The epinotum and pleuranotum are frequently separated (Fig. 9, *mng*) by a thin ridge, the marganotum. It is only a fine carina in many insects and its presence or absence is often of considerable systematic value.

Callosity.—There is sometimes a round convexity of varying size on each side of the meson of the epinotum, a callosity. The callosities are where the muscles of the legs or of the endoskeleton are attached to the ental surface of the epinotum.

Patagium.—The prominent cuticular lobes developed from the cephalic transverse folds of the pronotum in the Lepidoptera are known as the patagia, singular patagium. They are very large in some species, covered with long scales, and project over the mesonotum. They should not be confused with the tegulae, the scale-

like pads which cover the proximal ends of the mesowings and metawings.

Notalia.—The caudal portion of the pronotum is frequently infolded and the surfaces adjacent, forming a projection which covers a part of the mesonotum and mesopleura. This projection is the notalia. It is present in those insects where the prothorax is a large distinct area. The ventral wall of the projection, which is a continuation of the external cuticle, extends cephalad to the mesocoria. The notalia is also known as the posterior reduplication of the notum or the posterior notal ridge.

Blatta Orientalis.—The prothorax is strongly depressed and rhomboidal in outline. The sclerites of the sternum and pleura are broadly separated by membrane or coria.

Pronotum.—The pronotum occupies the dorsal and a part of each lateral aspect. The caudal end forms a distinct notalia. The epinotum is broader on the caudal than on the cephalic portion. It is bounded by a sharp marganotum. The pleuranotum is the longitudinal area on the ventral aspect, adjacent to the marganotum and closely appressed to the epinotum. The notasuture is distinct.

Draw the dorsal aspect of the prothorax.

Prosternum.—The prosternum occupies the mesal part of the ventral aspect. The legs should be removed by cutting transversely through the middle of the proximal segment. The procoxacoriae are large. The yellowish elongate shield-shaped mesal area caudad of the cervepimeron is the cephalic portion of the prosternannum. The lighter colored semitransparent broader area at the caudal end of the cephalic portion is the caudal portion of the prosternannum. There is a faint darker spot or pit located in each lateral margin of the caudal portion. Each is a profurcina and the delicate filament which can be seen through the cuticle attached to each profurcina is a profurca. The line extending around the convex caudal end of the prosternannum connecting the profurcinae is the suture limiting the caudal extent of the prosternannum. The small pit on the meson at some distance caudad of the prosternannum is the profurcellina. The distinct finger-like projection extending cephalad into the body from the profurcellina is the profurcella. The small brownish chitinized area bearing the profurcellina belongs to the prosternellum. There is a broad area of membrane along each lateral margin of the prosternannum and prosternellum. This membrane extends to the mesocoria, each coxacoria, and each pleuron. The two transverse sclerites located cephalad of each procoxacoria belongs to the protrochantin. The propretrochantin is suboval in outline with the mesal end bluntly pointed. The

mesal half of its cephalic margin is infolded as a parademe. The proparatrochantin is triangular in outline and located along the caudal margin of the propretrochantin. The suture between them is a dark infolded thickening. The mesal ends of the propretrochantin and proparatrochantin form a blunt protrocoila articulating in a distinct protrocartis. The lateral ends of the propretrochantin and proparatrochantin are free and articulate against the proepisternum. The minute sclerite with a long slender parademe located in each procoxacoria between a procoxa and a proparatrochantin is a procoxella. The two transverse sclerites located cephalad of each propretrochantin belong to the prosternoidea. The propresternoidea extends cephalo-laterad from near the prosternannum to near the mesal margin of the pleuranotum. Both ends are pointed and the lateral end is oblique and separated from the propleuron by an indefinite coria. There is a blunt projection near the middle of the cephalic margin against which the cervepimeron articulates. The proparasternoidea is much narrower and shorter than the propresternoidea and is usually folded under it and in great part concealed. Its lateral end is located near a notch in the margin of the propleuron and the mesal end extends to near the mesal end of the propresternoidea. There is a small brownish unnamed sclerite in the procoria cephalad of the lateral end of each propresternoidea. The prosternasutures and protrocasutures are distinct.

Propleuron.—Each propleuron is limited to the irregular area located between the pleuronotum of one side and the prosternoidea, protrochantin, and the coxacoria of the other. The small brownish projection at the middle of the lateral margin of each procoxacoria is a procoxacoila. It articulates against a procoxartis. The prominent furrow extending obliquely from the caudal side of each procoxacoila to the pleuranotum is a propleural suture. The large thin plate attached along the ental surface of the propleural suture is the propleuradema. The propleurademina is the elongate slit, difficult to identify, near the mesal end of each propleural suture. The irregular convex area located cephalo-mesad of the propleural suture and between it and the prosternoidea and the protrochantin is the proepisternum. There is a secondary suture extends caudolaterad from the notch near the lateral end of the proparasternoidea across the proepisternum to near the propleural suture. This suture, which is analogous in position, if not homologous, with an episternal suture, has been homologized as the lateral boundary of the protrochantin and the area mesad of it named the trochantinus major and the area here considered as the protrochantin named the

trochantinus minor. The sclerite located on the caudo-lateral side of the propleural suture is the proepimeron. It is connected for some distance with the pleuranotum. There is a long area of membrane caudad of each proepimeron. This membrane is continuous with the mesocoria.

Draw the ventral aspect of the prothorax and name all the parts.

Draw the ental surface of the ventral aspect of the prothorax and name all the parts.

MELANOPLUS DIFFERENTIALIS.—The prothorax is a large distinct area. Most of its sclerites are located on the ventral aspect.

Pronotum.—The saddle-shaped piece occupying the dorsal and the greater part of each lateral aspect is the pronotum. The cephalic margin is straight, the caudal margin is produced into a broad angular lobe, forming a prominent notalia. The cephalic and caudal margins converge on each lateral aspect and the ventral margin is broadly angular. The marganotum is broadly rounded so that the division between the epinotum and pleuranotum is not distinct. The median suture is represented by a carina. The surface of the pronotum is crossed by three distinct furrows known as sulci, which have been considered as sutures by some authors. The caudal and median sulci pass directly across the epinotum and nearly to the ventral margin of each pleuranotum. The cephalic sulcus is located near the median sulcus on the epinotum. It extends through the marganotum near which it bends abruptly cephalad, is obsolete for a short distance, and then bends ventrad near to and parallel with the cephalic margin of the pleuranotum. There is an oblique sulcus on the pleuranotum connecting the median and caudal sulci. The procoria is attached near the ental surface of the cephalic sulcus and the mesocoria near the caudal sulcus. The area on the epinotum caudad of the caudal sulcus is known as the metazona and the entire area cephalad of this sulcus as the prozona. The portion of the prozona cephalad of the cephalic sulcus is the prezona, that between the cephalic and median sulci is the interzona, and that between the median and caudal sulci is the parazona.

Draw the dorsal aspect of the prothorax and name all the parts.

Propleuron.—The sclerites of the propleuron are small. The triangular sclerite located at the cephalo-ventral angle of each pleuranotum, is a proepisternum. The greater part is concealed by the pleuranotum, which is infolded, forming a pocket between it and the proepisternum. This pocket extends dorsad over half way to the abrupt bend in the cephalic sulcus. The caudal end of the ventral portion of the proepisternum, which is covered by the pleuranotum, forms a blunt rounded projection. The ventral margin

of the pleuranotum should be bent back so as to expose this projection. The triangular sclerite mesad of the projection of the proepisternum and upon which it rests is the proepimeron. The sutures bounding it are not distinct. The proepimeron is completely concealed by the pleuranotum and proepisternum. The propleural suture is the deep furrow between the proepisternum and the proepimeron. The pronotasuture is concealed by the ventral margin of the pronotum. The caudal projection of the proepisternum should be bent back so as to expose this suture. The propleurademina is the minute pit at the ventral end of the propleural suture. The propleuradema is attached along the ental surface of the propleural suture and extends dorsad adjacent to the ental surface of the median sulcus. It is attached to the caudal margin of the portion of the proepisternum covered by the infolded portion of the pleuranotum. A profurca is fused to the ventral part of the mesal margin of each propleuradema. The brownish projection extending into the procoxacoria from the caudal end of the proepisternum is the procoxacoila. The propleuradema extends along its ental surface.

Draw the lateral aspect of the prothorax and name all the parts.

Prosternum.—The ventral aspect belongs to the prosternum. The procoxacoriae are large and located adjacent to the proepisterna and proepimera. The conical projection located between the procoxacoriae is the prosternal tubercle. The transverse line located caudad of the prosternal tubercle and connecting the middle of the mesal margins of the procoxacoriae marks the position of the profurcinae, which are closed. A subcylindrical profurca extends dorso-laterad from each profurcina and fuses with the angular part of a propleuradema. The profurcae are connected by a transverse mesal thickening. The circular depression at the caudal end of the infolded blackish mesal line caudad of the prosternal tubercle is the profurcellina. The blackish line marks the place of fusion on the thin plate-like profurcella with the ental surface of the prosternum. Its cephalic end is free. The area bearing the prosternal tubercle is the prosternannum. Its caudal boundary is the line marking the position of the profurcinae. The cephalic portion extends laterad as a narrow area cephalad of each procoxacoria to a proepisternum. The area located caudad of the prosternannum and bearing the profurcellina near its caudal margin is the prosternellum. It is membranous caudad of each procoxacoria. This membrane is continuous with the long mesocoria. The vertical area fused with each cephalo-lateral portion of the prosternannum against which a cervepimeron articulates represents a proster-

noidea. The dorsal end extends into a pocket under the proepisternum and pleuranotum. The totasuture is represented by a sharp ridge. The protrochantin consists of two sclerites. The propretrochantin is the oval sclerite located in each procoxacoria. It is vertical in position and its mesal end articulates in a distinct protrocartis. The proparatrochantin is the minute light colored sclerite located between the lateral end of the propretrochantin and the procoxacoila. The minute convex area located between the propretrochantin and the proparatrochantin is a procoxella.

Draw the ventral aspect of the prothorax and name all the parts.

Draw the ental surface of the ventral aspect of the prothorax and name all the parts.

Harpalus Caliginosus.—The prothorax is depressed and its cephalic end is deeply infolded, forming an opening in which the caudal fourth of the head is retracted. It is, as viewed from above, large, depressed, and quadrangular. The transverse area surrounding the deeply infolded cephalic portion of the prothorax is formed from the pronotum and the prosternum.

Pronotum.—The pronotum comprises the dorsal aspect and an inflexed portion on each side of the ventral aspect. The marganotum forms a sharp dividing line between the epinotum and the pleuranotum. The central area of the epinotum is the disk of the pronotum and its four corners or angles are the pronotal angles. The two cephalic angles are the anterior pronotal angles and the two caudal the posterior pronotal angles. The depressed flattened area near each posterior pronotal angle is a basal impression. The setae on each lateral margin of the epinotum are known as the pronotal setae and the calyces in which they are inserted as the pronotal setigerous punctures. There are usually two on each side, one near the middle of each lateral margin, the median pronotal setigerous puncture, and one on each posterior pronotal angle, the posterior pronotal setigerous puncture. The latter are wanting in this insect. The pleuranotum is a narrow area, except on the caudal fourth, where it is widened to meet the infolded caudal margin of the epinotum, forming a short notalia. The pronotasuture is distinct and deeply infolded. The pleuranotum is closely appressed against the epinotum.

Draw the dorsal aspect of the prothorax and name all the parts.

Propleuron.—The greater part of the area of each side adjacent to a pleuranotum belongs to a propleuron. The large opening on each side of the meson is a procoxacava. It is formed for the most part by the infolding of the adjacent parts of the prosternum. The procoxafossa is located in the lateral part of the bot-

tom of each procoxacava. The procoxacoriae are short. The convex triangular sclerite with rounded angles adjacent to three-fourths of the mesal margin of each pleuranotum is a proepisternum. Its mesal end is separated externally from the procoxacava by narrow prolongations of the prosternannum and proepimeron, which meet near the middle of the lateral margin of the procoxacava. The mesal end, however, projects dorsad of the plate formed by these sclerites and forms the lateral wall of the procoxacava and a procoxacoila. The sclerite along the caudal margin of each proepisternum extending from a pleuranotum to a procoxacava is a proepimeron. The mesal end is bifurcate. The cephalic projection is a narrow bar forming externally the lateral boundary of the procoxacava. It is separated from the prosternannum by an oblique suture near the cephalo-lateral angle of the procoxacava. The caudal projection is a broader bar extending mesad along the caudal margin of the procoxacava to the short longitudinal suture beyond the middle of each procoxacava. Here it unites with a lateral projection from the mesal area of the prosternannum. The union of a proepimeron with a prosternannum caudad of a procoxacava produces the condition where the procoxacava is said to be closed. The caudal portion of each proepimeron is infolded, the lateral end uniting with the infolded portion of the pleuranotum and the mesal end with the prosternannum. The propleural suture is distinct. The propleurademina can not be identified. The propleuradema extends as a plate along the ental surface of each propleural suture. It is larger near the procoxacoria.

Prosternum.—The prosternum comprises the area mesad of the propleura. All of the exposed part of the prosternum belongs to the prosternannum with which the prosternoideae are indistinguishably fused. On the cephalic part of the ventral aspect the prosternannum extends between the pleuranota and forms the cephalic boundary of the proepisterna. The totasutures are distinct and infolded. The lateral end of this infolded plate is fused with the infolded cephalic portion of the prosternannum, forming the ventral side of the opening in which the head is inserted. The prosternannum at the cephalo-lateral angle of each procoxacava is angular and joins externally the cephalic prolongation of the proepimeron, the two separated by an oblique suture. The portion of the sternannum between the procoxacavae on the ventral aspect is narrow and bluntly rounded at its caudal margin with a transverse row of setae inserted in calyces, the prosternal setigerous punctures. The prosternannum extends dorsad from these punctures as a vertical convex area, broadest at its dorsal end, where a prolonga-

tion on each side joins the portion of a proepimeron extending along the caudal side of a procoxacava. The prosternannum then extends cephalad as a horizontal area, narrower at its cephalic end, to the middle of the procoxacava. The portion of the prosternannum on the external surface and its vertical portion adjacent to the procoxacavae are fused into a single plate, forming a thin wall between the procoxacavae. The infolded portion is also fused with the lateral margins of the horizontal portion of the prosternannum. There is a small finger-like projection extends into the body-cavity from each lateral margin of the dorsal horizontal portion of the prosternannum. These are the profurcae. The profurcinae are rounded pits located near the middle of the mesal margin of the bottom of each procoxacava. The profurcella and profurcellina are wanting. The membrane attached to the prosternannum adjacent to the profurcinae and extending caudad to the mesothorax represents the prosternellum and the mesocoria. The protrochantin is located at the bottom of each procoxacava and is more closely attached to the leg than to the sternum. It is usually removed with the leg and is attached to the cephalic margin of a procoxa in a distinct protrocartis. The lateral end is free in the procoxacoria. The protrochantin is rhomboidal in outline.

Draw the ventral aspect of the prothorax and name all the parts.

Draw the ental surface of the ventral aspect of the prothorax and name all the parts.

Calosoma Calidum.—The prothorax is short and thick. The cephalic end is deeply infolded, forming a cavity in which the cervix and the caudal part of the head are retracted. The prothorax as viewed from above is much broader than long, is about as high as broad, and is not depressed. The infolded area at the cephalic end is formed from the pronotum and prosternum. Its cephalic margin is fringed with setae.

Pronotum.—The pronotum includes the dorsal aspect and an inflexed area on each lateral aspect which is broader at the cephalic and caudal ends. The marganotum is sharp and distinct. The central area of the epinotum, the disk of the pronotum, is convex with a median furrow. Its four angles, the pronotal angles, are rounded, the two cephalic are the anterior pronotal angles and the two posterior, the posterior pronotal angles. The epinotum is distinctly depressed adjacent to the posterior pronotal angles, the basal impressions, which are connected by a shallow depression, the transverse depression. The setae and calyces placed along each lateral margin of the epinotum, the pronotal setae or setigerous punctures, are usually two in number, the one located on each side

near the middle of the lateral margin is the median pronotal setigerous puncture. The posterior pronotal setigerous puncture, located on the posterior pronotal angle, is wanting in this species. The ventral margin of the pleuranotum is concave.

Draw the dorsal aspect of the prothorax and name all the parts.

Propleuron.—The area adjacent to the mesal margin of each pleuranotum, except a small portion at the cephalic end, is a propleuron. The large opening on each side of the meson is a procoxacava. A procoxafossa is located in the lateral part of the bottom of each procoxacava. The procoxacoria is short. The triangular plate adjacent to three-fourths of the mesal margin of each pleuranotum is a proepisternum. Its cephalic and caudal margins converge toward the procoxacava. The ventral end does not reach the procoxacava externally, from which it is separated by projections of the prosternannum and the proepimeron. It extends, however, dorsad of these projections and is the plate bounding the lateral side of the procoxacava and forms a procoxacoila. The pronotasutures are distinct and infolded. The plate along the caudal margin of each proepisternum is a proepimeron. It extends from the pleuranotum to the procoxacava. The ventral portion is the broadest and its angles are prolonged and pointed. The cephalic prolongation extends to the middle of the lateral margin of the procoxacava, where it joins a narrow prolongation of the prosternannum. These prolongations are separated by a faint oblique suture. The caudal prolongation extends ventrad along the caudal margin of the procoxacava to near its middle, where it ends in the membrane as a blunt point. The space between the end of the caudal prolongation and the prosternannum is filled with membrane. This is the condition when the procoxacavae are said to be open, that is, not completely surrounded by sclerites. Each proepimeron is infolded upon itself and the dorsal end is united with the infolded end of the pleuranotum. The propleural suture is distinct. The propleurademinae are closed. Each propleuradema extends as a plate, larger near the procoxacoria, along the ental surface of the propleural suture. It is fused for the greater part of its length with the cephalic margin of the infolded portion of the proepimeron.

Prosternum.—The mesal area located mesad of each propleuron is the prosternum. All of the exposed parts of the prosternum belong to the prosternannum, with which the prosternoidea are fused. Each cephalo-lateral portion extends to the pleuranotum and forms the cephalic boundary of a proepisternum, from which it is separated by an infolded suture, the totasuture. The portion

adjacent to each cephalo-lateral angle of a procoxacava is produced as a narrow bar along the lateral margin of the procoxacava until it meets the cephalic projection of a proepimeron, from which it is separated by an oblique suture. The prosternannum extends caudad between the procoxacavae as a narrow tongue-shaped area, truncate at its caudal end, as seen from the ventral aspect. The caudal margin of this tongue-shaped area is infolded upon itself and extends cephalad, forming near to the ventral external surface a dorsal portion which extends as a free projection over the mesosternum. This dorsal surface curves dorsad to the procoxacoriae, where it terminates as a transverse brownish bar-like area. The prosternannum, when it curves dorsad, forms a keel separating the procoxacavae in part. The cephalic and mesal walls of the procoxacavae are formed in part by the infolding of the adjacent parts of the prosternannum. The profurcinae are the pits located near the mesal margin of the procoxafossae in the dorsal portion of the prosternannum. The profurcae extend from the profurcinae as flattened finger-like lobes into the body-cavity. The profurcella and profurcellina are obsolete. The membrane attached to the prosternannum adjacent to the profurcinae and extending caudad to the mesothorax represents the prosternellum and the mesocoria. The small irregular sclerite located in each procoxacava is a protrochantin. It is articulated in a protrocartis in the cephalo-lateral part of the proximal end of a procoxa. The other end of the protrochantin lies free in the procoxacoria. It has a distinct furrow on the ectal surface which fits over the edge of a procoxacoila.

Draw the ventral aspect of the prothorax and name all the parts.

Draw the ental surface of the ventral aspect of the prothorax and name all the parts.

3. MESOTHORACIC AND METATHORACIC STERNA AND PLEURA

The mesothorax and metathorax in all wing-bearing insects are closely associated. They are so closely associated and so distinctly separated from the prothorax in many insects that the thorax appears to consist of two regions instead of three. Where the three thoracic segments are closely amalgamated, the number, shape, and arrangement of the sclerites of the prothorax are very different from those of the other thoracic segments.

The mesothorax is frequently, particularly in specialized insects where the organs of flight are highly specialized, much larger than either the prothorax or the metathorax. The mesothoracic wings are usually stronger than the metathoracic and, whether larger or smaller, generally require more space for the accommoda-

tion of the muscles that operate them. There is no corresponding enlargement of the metathorax correlated with the enlargement and development of the metathoracic legs for jumping or swimming.

The size and form of the sclerites of the sterna and pleura are correlated with the size and freedom of the segments. The simplest type is always found in those insects where the prothorax is a large distinctly separated area. The cockroach shows the most primitive type, where the sternum and pleura of the prothorax is more generalized than these regions in the other segments. The prothorax is generally more modified than the mesothorax and metathorax, even though these segments are similar in size and in the arrangement of their sclerites. There has been a great increase in the size of the pleura and sternum of the mesothorax and a corresponding reduction in the size of these parts in the metathorax. Such a reduction is frequently found in those insects where there has been a great modification in the size of the prothorax, but is not limited to these alone, for it is found in many insects where the prothorax is a large distinctly separated region.

The sternasutures and trocasutures are distinct in certain generalized insects and there is no difficulty in separating the sterna from the pleura. These sutures in most insects are obsolete and there is a continuous chitinized undivided area extending across the pleura and sternum between the wings. It is impossible in those cases where the sternasutures are obsolete to decide absolutely just how much of this area should be assigned to the sternum and how much to the pleura. Some general rule is desirable, however, in subdividing this area. In such an insect as the cockroach, the sternannum and sternellum form the mesal area of the sternum, the sternoideae and trochantins occupy the areas cephalad of the coxacoriae, while the caudal side of the coxacoriae in many insects is bounded by the sternellum. The coxacoriae are bounded, therefore, on the cephalic, mesal, and caudal sides by parts of the sternum. It has been assumed that in those insects where the sternasutures and trocasutures are obsolete that all of the area extending between the segmacoriae and the lateral margins of the coxacoriae belongs to the sternum.

Specimens for the study of the sterna and pleura of the mesothorax and metathorax should have the dorsal aspect of these segments removed. The caudal part of the prothorax should be left attached to the mesothorax and one or two of the cephalic abdominal segments should be left attached to the metathorax. The legs, except a small proximal portion of each coxa, should be removed.

The specimens should remain in caustic potash until the attachments of the muscles are destroyed and the internal parts can be removed. The preparations should be handled with care so as not to tear the delicate membranous parts and break or disconnect the parts of the entosternum and entopleuron. The specimens should be studied in seventy per cent alcohol. The drawings of the pleuron should all be of the same size. If the ectal surface of the dextral pleuron is drawn, the ental surface of the sinistral pleuron should be drawn.

Spiracles.—The external openings of the respiratory system are located typically in the transverse coria between the segments and are known as spiracles, also as stigmata. The invaginations for the respiratory system arise early in embryonic development (Fig. 4) in the cephalic part of the segment, so that the openings or spiracles belong to the segment caudad of them. Embryologists have shown that in the embryos of certain insects the prothoracic spiracles migrate cephalad through the labial segment, fuse on the meson, and form the opening for the mouth of the salivary duct. Whether this is true for all insects or not, has not been proven. The prothoracic spiracles are, however, wanting in all adult and immature insects. The spiracles found on the prothorax of certain larvae are the mesospiracles which have migrated from the mesocoria onto the prothorax. The mesospiracles are rarely, if ever, wanting. Those of the metathorax are sometimes wanting. The thoracic spiracles are located typically on the lateral aspect, but have migrated in many specialized insects onto the dorsal aspect.

Peritreme.—Each spiracle is usually surrounded and supported (Fig. 9, *prm*) by a cuticular plate, the peritreme, which is sometimes subdivided into two or more areas. The parts of the peritreme are also known as the interpleurites and as the intersegmentalia. The portions of the peritreme bounding the spiracle, the lip or labia, are frequently different in form from the other parts.

Prelabia.—The lip-like modification of the portion of the peritreme bounding the cephalic side of the spiracle (Fig. 9, *pra*) is the prelabia.

Postlabia.—The lip-like modification of the portion of the peritreme bounding the caudal side of the spiracle (Fig. 9, *ptb*) is the postlabia.

Alifera.—The projections of the pleuron against which the pteraliae or wing-sclerites articulate, are the aliferae. They consist of a prominent projection formed from the adjacent parts of the episternum and epimeron, the pleuralifera, and some small sclerites located in the notacoria. The sclerites located on the

cephalic side of the pleuralifera are also known as the episternal paraptera, preparaptera, or basalare and those on the caudal side as the epimeral paraptera, postparaptera, or subalare and collectively as the paraptera or alarpleurites.

Pleuralifera.—The portion of the episternum and epimeron adjacent to the mesopleural and metapleural sutures (Fig. 9, *plf*) forms a prominent pillar-like projection, the pleuralifera, against which the pteraliae articulate. It is divided into two parts, at least in generalized insects, by the pleural suture. Each is also known as a pleural wing process, clavicula alae, ascending process, or alar process.

Prealifera.—The cephalic of the two sclerites located cephalad of the pleuralifera (Fig. 9, *pef*) is the prealifera. It is usually a large distinct sclerite and is also known as the anterior basalare.

Medalifera.—The alifera located between the prealifera and the pleuralifera (Fig. 9, *mdf*) is the medalifera. It is also known as the posterior basalare and is frequently covered by or fused with the prealifera. The prealifera and medalifera are also known collectively as the episternal paraptera or preparaptera, hypoptere and paraptere, alarpleure, and first and second parapteron.

Postalifera.—There is typically only a single alifera located on the caudal side (Fig. 9, *ptf*) of the pleuralifera. This is the postalifera, also known as the anterior subalare, postparaptera, epimeral paraptera, costale, postepimeron, costal sclerite, posterior costal sclerite. It is a long narrow sclerite, usually the largest of the aliferal sclerites.

Micralifera.—The minute sclerite located caudad of the postalifera (Fig. 9, *mif*) is the micralifera. It is only rarely present and is also known as the posterior subalare.

Interpleural Suture.—The portion of the metacoria between the pleural sclerites is frequently reduced to a suture. It is then known as the interpleural suture and is sometimes partly or completely obsolescent.

Episternal Suture.—The episterna are frequently divided by secondary sutures (Fig. 9, *esr*) into dorsal and ventral areas. These sutures are formed in different ways, but usually by the fusion to the ental surface of the episternum of a cephalic projection from the pleuradema. It forms the cephalic part of the so-called sternopleural suture of authors.

Notepisternum.—The portion of the episternum on the dorsal side of the episternal suture (Fig. 9, *ns*) is the notepisternum. It is also known as the mesopleura or anepisternum.

Sternepisternum.—The portion of the episternum on the ven-

tral side of the episternal suture (Fig. 9, *ses*) is the sternepisternum. It is usually continuous with the sternannum and is also known as the sternopleura, katepisternum, or sternopleurite.

Epimeral Suture.—The epimera are frequently divided by secondary sutures (Fig. 9, *eps*) into dorsal and ventral areas. These sutures are usually formed by the fusion to the ental surface of the epimeron of the caudal projection from the pleuradema. It forms the caudal part of the so-called sternopleural suture of authors. The episternal and epimeral sutures only rarely form a single continuous suture. There is usually a distinct offset.

Notepimeron.—The portion of the epimeron on the dorsal side of the epimeral suture (Fig. 9, *nm*) is the notepimeron. It is also known as the pteropleura, anepimerum, or pteropleurite.

Sternepimeron.—The portion of the epimeron on the ventral side of the epimeral suture (Fig. 9, *sep*) is the sternepimeron. It is frequently continuous with the sternellum and is also known as the meropleura, hypoepimeron, or katepimerum.

Rotaxis.—Each wing is composed of two closely appressed layers of cuticle. One of these layers is continuous with the cuticle of the pleuron and the other with that of the notum. The space between them connects the vein-cavities with the body-cavity. These layers of cuticle by which the wing is joined to the body, a part of the notacoria, is thin and membranous and contains the small scleries and projections, the pteraliae, which articulate against the notum and pleuron. This expanded portion of the notacoria which contains the pteraliae is the rotaxis. It is also known as the axillary membrane.

Notarotaxis.—The layer of cuticle continuous with the dorsal surface of the wing and the notum is the notarotaxis. The most of the pteraliae are located in this layer.

Pleurotaxis.—The layer of cuticle connecting the ventral surface of the wing and the pleuron is the pleurotaxis. Some of the larger pteraliae extend from the notarotaxis into the pleurotaxis.

Prealaralia.—The adjacent parts of the praescutum and episternum are frequently fused, forming a connection cephalad of the rotaxis, the prealaralia, also known as the prealare.

Postalaralia.—The adjacent parts of the postscutellum and epimeron are generally fused, forming a connection caudad of the rotaxis, the postalaralia, also known as the postalare. The prealaraliae and the postalaraliae are known collectively as the alaraliae.

Hyposternum.—There is a narrow transverse area along the cephalic margin of each mesepisternum, the caudal margin of which

is bounded by a slight ridge marking the extent of the overlapping of the prothorax onto the mesothorax. This area is the hyposternum. It is frequently continuous across the mesosternannum. In a few genera of hymenopterous insects, the ridge is modified into a suture-like furrow. The hyposternum is also known as the peristernum, preepisternum, katopleura, prĕpectus, or praesternum.

Disca.—The ental surface of certain parts of the body, particularly the aliferae and pteraliae, have a large muscle or a parademe, a pronator muscle, attached to them. The place of attachment shows on the ectal surface as a disk or ring and is known as a disca. The periphery of the disca on the ental surface is usually produced into a lamellate parademe. The parademe is frequently large and dilated at the free end.

Ponta.—There is a small transverse sclerite in most Diptera which connects the margin of the mesoscutum and the mesoprealifera, separating the mesonotacoria from the mesorotaxis. This sclerite is the ponta.

Intersternum.—The pleural sclerites in the Odonata are strongly oblique and their dorsal ends are directed caudad instead of cephalad or dorsad. There is formed as a result of this change in direction a large secondary area on the ventral aspect caudad of the metasternum and between the metepimera. This area is well chitinized and is apparently formed from the unacoria. It is known as the intersternum, also known as the postpleurite or opisthopleurite.

Blatta Orientalis.—The mesosternum and metasternum occupy the greater part of the ventral aspect. The median and lateral fields are easily identified. The mesopleura and metapleura are located laterad of their sterna. The male shows the structures in connection with the articulation of the wings more distinctly than the female.

Mesosternum.—The prosternum of this insect represents a primitive type. The mesosternum should be compared with it. The mesocoxacoriae are large. The mesal area extending from the mesocoria, located near the profurcella, to and including the arms of the inverted Y located between the mesocoxacoriae belongs to the mesosternannum. It consists of a brownish subquadrangular area, rarely two adjacent areas, located on the cephalic two-thirds together with the Y-shaped area. Each mesocoxacoria is continuous with the membrane on each side between these areas. The area located between the arms of the inverted Y and the metacoria is the mesosternellum. It is membranous, except for a mesal brownish club-shaped area. The ring at each end of an arm of the inverted

Y of the mesosternannum is a mesofurcina. The mesofurcae extend laterad from the mesofurcinae as long slender finger-shaped arms. The mesal ring adjacent to the metacoria is the mesofurcellina. The mesofurcella is a minute finger-shaped lobe. The two transverse sclerites articulating against each lateral margin of the cephalic brownish area of the mesosternannum belong to a mesosternoidea. Each mesopresternoidea is a large oblique suboval area. Its lateral end is not free as the propresternoidea, but is fused with the mesepisternum. The mesoparasternoidea is the shorter and narrower area, pointed at its lateral end, and located along the caudal margin of the mesopresternoidea. The two transverse sclerites located between each mesosternoidea and a mesocoxacoria belong to a mesotrochantin. The mesopretrochantin is the sclerite located along the caudal margin of the mesoparasternoidea. There is a deep transverse fold of coria between the mesoparasternoidea and the mesopretrochantin, so that only the mesal end of the latter is ordinarily exposed. The mesopretrochantin is sublanceolate in outline, largest at its mesal end. The mesoparatrochantin is the much larger triangular sclerite located along the caudal margin of the mesopretrochantin. The mesal and lateral ends of the mesopretrochantin and mesoparatrochantin are fused, but the limits of the sclerites are easily determined. The intermediate part of the suture is membranous. The fused mesal end forms a broad truncated mesotrocoila articulating in a distinct mesotrocartis. The lateral end of each mesotrochantin is separated from a mesepisternum by a distinct longitudinal suture, a part of the mesosternasuture. The small oval area located in each mesocoxacoria near the cephalic margin of the mesocoxa is a mesocoxella.

Mesopleuron.—The narrow area on each side between the mesosternum and the dorsal aspect is a mesopleuron. The oval area located in the mesocoria between the lateral end of each procoxacoria and a mesosternoidea is a mesoperitreme. The mesoprelabia is a convex semicircular lip which is much larger than the mesopostlabia. The oblique strongly convex area fused with the lateral end of each mesopresternoidea is a mesepisternum. Its caudolateral boundary is a deep furrow, the mesopleural furrow, at the bottom of which there is a distinct mesopleural suture. Each mesepisternum is triangular, its cephalo-lateral portion is not strongly chitinized, and the caudo-mesal portion adjacent to the articulation of a mesocoxa, is produced into a dark brownish mesocoxacoila. The oblique strongly convex area located caudo-laterad of the mesopleural suture is the mesepimeron. It is deeply emarginate adjacent to the mesocoxacoria. Its caudal boundary is the

metacoria and its dorsal boundary is the mesonotacoria. The small brownish projection at the cephalo-lateral end of each mesopleural furrow is a mesopleuralifera. Its end is curved and bluntly rounded. The mesopleural furrow can be traced to the end of the projection. It is more distinct in the male. The mesopleurademina is the opening in the caudo-mesal portion of each mesopleural suture. The mesopleuradema extends as a horn-shaped lamella along this suture. It is fused at its ventral end with a mesocoxacoila. The mesoprealifera in the female is the angular projection dorsad of each mesepisternum and cephalad of the mesopleuralifera. The mesomedalifera is wanting or fused with the mesoprealifera. In the male the mesoprealifera is similarly placed, it is completely separated from the mesopleuralifera and mesepisternum, and has a minute round knob on its lateral end. The mesomedalifera is obsolete. The mesopostalifera is obsolete in the female. In the male it is the longitudinal sclerite located in the mesopleurotaxis in line with the mesopleuralifera. It is not strongly chitinized and its cephalic end is near the mesopleuralifera.

Draw the mesosternum and dextral mesopleuron and name all the parts.

Draw the ental surface of the mesosternum and sinistral mesopleuron and name all the parts.

Metasternum.—The metasternum is similar in form to the mesosternum and should be compared with it. The metacoxacoriae are similar in size and shape to the same structures of the mesosternum. The mesal area extending from the metacoria to and including the arms of the inverted Y located between the metacoxacoriae belongs to the metasternannum. It contains two large subquadrangular brownish areas on the cephalic two-thirds, larger and more distinctly separated than the same areas of the mesosternannum, and the area forming the inverted Y. The mesal membranous area sometimes is modified into a chitinized plate. Each metacoxacoria is continuous with the membrane between the lateral and Y-shaped areas. The cephalic brownish areas are at a different level than the adjacent parts. The metasternellum is entirely membranous. It includes the small area caudad of the arms of the inverted Y which is continuous with the unacoria. There is a metafurcina located at the caudal end of each arm of the inverted Y. The metafurcae extend laterad as long finger-shaped tubular projections. The metafurcella is wanting. The two transverse sclerites belonging to the metasternoidea are similar in position to those of the mesosternoidea. The lateral end of each metapresternoidea is fused with the metepisternum and its mesal end articulates against a lateral margin of the cephalic brownish areas of the metasternan-

num. The metaparasternoidea is similar in shape to the mesoparasternoidea. The mesal part of the suture between the metapresternoidea and the metaparasternoidea is obsolete. The mesal end of the latter articulates against the lateral margin of one of the cephalic brownish areas of the metasternannum. The metatrochantins differ from the mesotrochantins only in being slightly larger. The mesal ends of the metapretrochantin and metaparatrochantin are fused, forming a large metatrocoila articulating in a distinct metatrocartis. The metacoxellae are long and distinct.

Metapleuron.—The metapleuron is similar in form and position to the mesopleuron. There is a metaperitreme and metaspiracle located in the metacoria cephalad of the lateral end of each metapresternoidea. They differ from the mesoperitreme in that the metapostlabia is large and semicircular, much larger than the metaprelabia. The metepisternum is similar in size and general shape to the mesepisternum. The oblique metapleural furrow along its caudal margin is distinct, at the bottom of which there is a metapleural suture. The projection at the caudo-mesal end of the metapleural furrow is the metacoxacoila. The metepimeron is strongly convex. The dorsal part of the convexity is angularly produced. The ventro-caudal end, caudad of the metacoxacoila, is emarginate and bounds a metacoxacoria. The metapleuralifera in the female is similar to the mesopleuralifera. In the male it is a rounded projection dilated into a bluntly rounded point on the caudal side. The metapleurademina is located in the caudo-mesal portion of the metapleural suture. The metapleurademae are similar in shape to the mesopleurademae and slightly larger. The metaprealifera in the female is similar in size and shape to the mesoprealifera. The suture separating it from the metapleuralifera is distinct. The metamedaliferae are obsolete in both sexes. In the male the metaprealifera is a subquadrangular area located cephalad of the metapleuralifera. It is completely separated from the metepisternum and its cephalic margin is bounded by a lateral projection of the metepisternum. Its caudal margin is thickened. The metapostalifera is similar in appearance and location to the mesopostalifera.

Draw the metasternum and the dextral metapleuron and name all the parts.

Draw the ental surface of the metasternum and sinistral metapleuron and name all the parts.

Gryllus Pennsylvanicus.—This insect shows an intermediate stage between the generalized condition found in the cockroach and the condition found not only in the grasshopper but in most insects. The trochantins are reduced in size and articulated

to the coxae. The sternoideae are much smaller and interpolated between the sternannum and episterna. The thorax is four-sided.

Mesosternum.—The mesocoxacoriae are large. The mesocoria is long. The large mesal quadrangular area of the ventral aspect is the mesosternannum. The caudal portion of each lateral part and the caudal margin is infolded. The caudal margin rests upon the metasternum and conceals the infolded portion. There is a large depression in the cephalic part of the infolded portion, which contains a large pit on each side of the meson, a mesofurcina. The mesofurcae are prominent tubular structures which extend dorso-laterad from the mesofurcinae. The small area located caudad of the mesofurcinae is the mesosternellum. The suture between the mesosternannum and mesosternellum is obsolete. There is a distinct pit near the middle of the mesosternellum, the mesofurcellina, which connects with a short mesal projection, the mesofurcella, the dorsal end of which is modified into several lamellae. The ventral portion of the mesofurcella is continuous with the mesofurcae. There are three sclerites located in the mesocoxacoria cephalad of each mesocoxa. The minute lateral sclerite with a thread-like parademe is a mesocoxola. The small oval sclerite with a prominent lamella-like parademe mesad of each mesocoxaola is a mesocoxella. The large transverse sclerite cephalad of each mesocoxella is a mesotrochantin. The mesopretrochantin and mesoparatrochantin are fused to form this single area. The lateral end is largest and articulates against a mesepisternum. The mesal end is modified into a mesotrocoila articulating in a mesotrocartis. The subquadrangular area cephalad of each mesotrochantin and laterad of the mesosternannum is a mesosternoidea. The mesopresternoidea and mesoparasternoidea are fused and form this single area. The mesosternasuture and mesotrocasuture are distinct.

Mesopleuron.—The area dorsad of each mesosternoidea is a mesepisternum. Its caudal boundary is a distinct mesopleural furrow with a mesopleural suture at its bottom. The slit at the ventral end of the mesopleural furrow is a mesopleurademina. It connects with a horn-shaped mesopleurадема, which extends dorsad as a lamella along the ental surface of the mesopleural furrow. The ventral end of this furrow forms a prominent mesocoxacoila. The cephalic portion of each mesepisternum is not strongly chitinized. The swollen area located in the mesocoria and resting upon the less chitinized area is a mesoperitreme. The mesospiracle is oblique and opens caudad. The mesoprelabia is a convex lip covering the mesospiracle and mesopostlabia. There is an elongate unnamed sclerite in the mesocoria along the cephalic margin of each mesepi-

sternum. The oblique area caudad of the mesopleural suture is the mesepimeron. Its caudal margin is submembranous and continuous with the long metacoria, which is infolded. A mesepimeron forms the caudal part of each mesopleuron. The ventral end is fused to the mesocoxacoila. The dorsal end of the mesopleural furrow is modified into a mesopleuralifera, which consists of three minute bluntly rounded thickened projections. The large sclerite articulating against the mesepisternum adjacent to the mesopleuralifera is the mesomedalifera. The minute slightly chitinized subtriangular area at its cephalic end is the mesoprealifera. The small suboval area located adjacent to the dorsal margin of the mesepimeron is the mesopostalifera.

Draw the mesosternum and dextral mesopleuron and name all the parts.

Draw the ental surface of the mesosternum and the sinistral mesopleuron and name all the parts.

Metasternum.—The metasternum is very different in form and structure from the mesosternum. The metacoxacoriae are large and located in the caudo-lateral part of the ventral aspect. The large mesal area extending between the metacoxacoriae is the metasternannum. Its caudal and lateral margins are deeply infolded and the latter are continuous with the metacoxacoriae. The caudal margin of the exposed portion of the metasternannum is concave and covers a part of the unasternum. The metasternannum is continued into the infolding as a narrow mesal area with a prominent depression at its caudal end. The opening on each side of this depression is a metafurcina. Each connects with a tubular metafurca, which is similar in size and shape to a mesofurca. The transverse brownish area located near the middle of the cephalic portion of each metacoxacoria is a metatrochantin. The metacoxella and metacoxola are obsolete. Each lateral infolded portion of the metasternannum is membranous and continuous with the membranous metasternoidea and the submembranous ventral portion of the metepisternum.

Metapleuron.—The transverse swollen area located in the metacoria near the ventral end of each mesepimeron is a metaperitreme. The metaspiracle is located in the dorso-cephalic portion and opens cephalad. The metapostlabia is a semicircular convex lip fitting over the metaprelabia. The cephalic area of each metapleuron is a metepisternum. Its caudal boundary is an oblique metapleural furrow with a metapleural suture at bottom. The sclerite on the caudal side of the metapleural suture is the metepimeron. Its ventral portion is narrower than the dorsal. The ven-

tral part of the metapleural furrow is deeply infolded. Its sides are thickened and produced into a metacoxacoila, formed from the metepisternum and metepimeron. The slit located in the metapleural furrow near the metacoxacoila is the metapleurademina. The metapleuradema is a horn-shaped lamella. It supports the ental surface of the metacoxacoila and extends dorsad as a lamella along the ental surface of the metapleuralifera. Its dorsal end is dilated and the caudal angle prolonged. The folded subtriangular sclerite articulating against the cephalic margin of the metapleuralifera is the metamedalifera. The small irregular transverse area fused to its cephalic end is the metaprealifera. The long sclerite with rounded ends located in the metapleurotaxis dorsad of the metepimeron is the metapostalifera. The oval sclerite caudad of it is the metamicralifera.

Draw the metasternum and the dextral metapleuron and name all the parts.

Draw the ental surface of the metasternum and the sinistral metapleuron and name all the parts.

Melanoplus Differentialis.—The mesothorax and metathorax are four-sided. The division of the sterna into a median and a lateral field is obliterated.

Mesosternum.—The mesosternum occupies the ventral aspect. It is much larger than the prosternum. The mesocoxacoriae are large and located in the caudo-lateral part of the mesosternum between the ventral and lateral aspects. Each is bounded on the mesal and cephalic margin by a crescentic area, the mesosternola. It is a modification of the mesosternoidea and mesepisternum and is limited by an infolded furrow forming a secondary suture. The faint furrow extending from the mesal part of the furrow limiting each mesosternola to the mesocoria is a rudiment of the suture between the mesosternannum and a mesosternoidea. This furrow and suture, the mesotrocasuture, forms the lateral boundary of the mesosternannum, which extends from the mesocoria to the dove-tailed area between the mesocoxacoriae. This dove-tailed area is bounded by a distinct infolded thickened suture. The mesal part of the thickening of the dove-tailed area is formed by the infolding and fusion of the two surfaces of the mesosternellum, which shows externally only as a line and internally as a lamella. The metasuture, separating the mesosternellum from the metasternum, is obsolete. The blackish pit located at each end of the thickening marking the position of the mesosternellum is a mesofurcina. The ventral part of each mesofurca is cylindrical, the dorsal half is bifurcate, one portion extending cephalad as a slender pointed arm

and the other caudo-laterad as a broad folded arm. The mesofurcellina is generally closed, the mesal black spot marks its position. The mesofurcella is a compressed mesal projection. The small suboval area located in the cephalic part of each mesocoxacoria is a mesotrochantin. The mesal end is modified into a mesotrocoila. The minute sclerite with a long parademe located near the lateral end of each mesocoxacoria is a mesocoxella.

Mesopleuron.—The cephalic part of each mesopleuron is concealed by the notalia. The small suboval area located in the middle of each lateral part of the mesocoria is a mesoperitreme. Its ventro-caudal angle is produced into a conical spine which supports the edge of the notalia. The mesospiracle, only about one-half the length of the mesoperitreme, is situated in the dorsal half of the mesoperitreme, and is directed caudad. The mesoprelabia is much larger than the mesopostlabia. The large transverse area adjacent to the mesocoria is the mesepisternum. Its cephalic margin is vertical and the caudal oblique. The mesepisternum and mesosternoidea of each side are fused through the obsolescence of the mesosternasuture. The dorsal end of the mesepisternum is deeply squarely emarginate with a pointed projection at the cephalo-dorsal angle. The black band along its caudal margin covers the mesopleural suture. The mesocoxacoila at the ventro-caudal angle is large and emarginate at the end. There is a diamond-shaped area, the adamanta, located between the cephalic end of the suture forming the lateral boundary of the mesosternannum and the mesoperitreme. It is separated from each mesepisternum by an infolded furrow forming a secondary suture. The transverse area located along the caudal margin of each mesepisternum is a mesepimeron. The distinct suture along its caudal margin covered by a black band is the interpleural suture. The mesopleuralifera is a large prominent projection. Its dorsal end is slightly dilated and emarginate. The mesopleural furrow can be traced across the mesopleuralifera to the emargination. The mesopleurademina is the opening located near the lateral end of each mesosternola. The mesopleurademia is the horn-shaped lamella extending mesad from each mesopleurodemina. It supports the ental surface of the mesocoxacoila and extends along the ental surface of the mesopleural suture as a prominent lamella to the dorsal end of the mesopleuralifera. The sclerite in the cephalic part of the dorsal emargination of each mesepisternum is a mesoprealifera. Its cephalo-dorsal angle is extended into a cone-shaped projection and its ental surface is supported by an oblique lamella. The small area located between the mesoprealifera and the mesopleuralifera is the mesomedalifera. The

line of separation between them is a transverse furrow. Its dorsal margin is concave. The sclerite located in the mesopleurotaxis and articulating against the dorso-caudal angle of the mesopleuralifera is the mesopostalifera. It is subtriangular in outline, the ventral margin is straight, the caudal end is pointed, and there is a deep rounded emargination on the dorsal margin.

Draw the mesosternum and the dextral mesopleuron and name all the parts.

Draw the ental surface of the mesosternum and the sinistral mesopleuron and name all the parts.

Metasternum.—The metasternum is broader than the mesosternum. The metacoxacoriae are small, infolded, and located on the lateral margin between the ventral and lateral aspects. Each is bounded on the mesal and caudal sides by a crescentic area, the metasternola. It is a modification of the metasternoidea and metepisternum. The portion on the mesal side of the metacoxacoria is much larger than that on the cephalic. Each metasternola is limited by an infolded furrow forming a secondary suture. The distinct oblique suture extending from the cephalic part of this furrow to the metacoria near a mesocoxacoria is the suture between the metasternannum and a metasternoidea, the metatrocasuture. This furrow and suture form the lateral boundary of the metasternannum. The mesal part of the cephalic end of the metasternannum is dove-tailed into the emargination in the mesosternum. The mesal part of the caudal margin is emarginate and the unasternum is dove-tailed into this emargination. The suture marking the caudal boundary of the metasternannum is the short thickened line forming the cephalic portion of this emargination. The metasternellum shows externally only as the thickened line at the cephalic end of the mesal emargination. It is transversely infolded and the infolded surfaces are fused. The mesal part of the unasuture is obsolete. The pit located at each lateral end of the thickened line marking the position of the metasternellum is a metafurcina. The proximal part of each metafurca is cylindrical. The distal part consists of a short blunt projection bearing a fine thread-like portion extending cephalad and a broad folded plate extending latero-caudad toward the pleuron. The metafurcellina is closed, its exact position can not be determined. The metafurcella is the distinct compressed mesal plate fused with the ventral ends of the metafurcae along the ental surface of the metasternellum. The small oval sclerite in the cephalo-mesal part of each metacoxacoria and articulating against the proximal end of a metacoxa is a metatrochantin. The minute round area located near the cephalo-mesal angle of each metacoxacoria is a metacoxella. It is situated in a

fold of membrane near the proximal end of the metacoxa. The large parademe, which it bears, will serve to identify it.

Metapleuron.—The metapleuron is very similar in general form and appearance to the mesopleuron. The small thickened area located on the cephalic side near the ventral end of each interpleural suture is a metaperitreme. The metaspiracle is short. The metapostlabia is a convex lip covering the metaprelabia. The transverse area along the caudal side of the interpleural suture is the metepisternum. The ventral end is fused with the metasternoidea and separated from the metasternannum by an oblique suture, the metatrocasuture. The metasternasutures are obsolete. The metapleural suture is covered by a black band. The cephalo-dorsal angle of the metepisternum fits against the mesepimeron. The transverse sclerite along the caudal margin of the metepisternum is the metepimeron. Its cephalo-dorsal angle is extended and with the metepisternum forms a long slender metapleuralifera. The dorsal end is oblique, the cephalic portion is longer than the caudal and hooked, the caudal is short and broad. The metapleural suture can be traced across the metapleuralifera. The dorsal part of each metepimeron is membranous and continuous with the metanotacoria. Its caudal margin is concave. The metapleurademina is the distinct slit in the ventral end of the metapleural furrow. The metapleuradema is similar in size and shape to the mesopleuradema. It supports the metacoxacoria, which is formed from the metepisternum and metepimeron, and extends along the metapleural suture onto the ental surface of the metapleuralifera, which it supports. The oblique sclerite located in the metapleurotaxis cephalad of the metapleuralifera and articulating against it at two points is the metamedalifera. Its cephalic end articulates against the caudal end of a large oblique sclerite, the metaprealifera, which articulates in a slight acetabulum in the dorso-caudal part of the mesepimeron. Its dorsal margin is thickened and produced into two parademes. The surface of the metamedalifera is stiffened by a parademe with radiating lamellae. The trumpet-shaped sclerite located caudad of the metapleuralifera is the metapostalifera. The flaring end of the trumpet is directed caudo-ventrad and forms a disca. The pointed cephalo-dorsal end articulates against the metapleuralifera.

Draw the metasternum and dextral metapleuron and name all the parts.

Draw the ental surface of the metasternum and the sinistral metapleuron and name all the parts.

Harpalus Caliginosus.—The body is depressed and the sclerites of the sterna and pleura are located for the most part on

the ventral aspect. The adjacent margins of the sclerites appear to be completely fused, they are, however, deeply infolded and easily separated in treated specimens.

Mesosternum.—The mesosternum is the mesal subtriangular area. The mesocoxacavae are subadjacent and formed by the infolding of the adjacent parts of the mesosternum and metasternum. The mesocoxacoriae are small and concealed in the cephalic part of the mesocoxacavae. The mesocoxae are said to be closed when, as in this insect, they are completely surrounded externally by the mesosternum and metasternum, so that the mesepimera do not reach the mesocoxacavae. The mesosternoideae are completely fused with the mesepisterna. The exposed part of the mesosternum belongs to the mesosternannum. The suture along each lateral margin is a mesotrocasuture. The cephalic end of the mesosternannum is narrow and slightly infolded and marked by a distinct hyposternum. The mesotrocasutures are divergent caudad and extend to the middle of the lateral margin of each mesocoxacava, bounding a blunt projection. The mesal portion of the mesosternannum extends between the mesocoxacavae as a shield-shaped mesosternal process, concave at the caudal end. The metacoxal process articulates in the concavity. The cephalic half of each mesocoxacava is formed for the most part from the infolded caudal portion of the mesosternannum. The distinct pit on each side of the mesosternal process in the dorsal wall of the mesocoxacavae is a mesofurcina. Each mesofurca extends dorsad and laterad as a stout lamella and fuses with a mesopleuradema. The mesofurcella is obsolete. The small area located caudad of the mesofurcinae within the mesocoxacavae is the mesosternellum. The portion of the mesocoria between the mesosternum and metasternum is concealed externally. It can be located within the mesocoxacavae. The small sclerite located in the cephalo-lateral part of the mesocoxacoria near the proximal part of each mesocoxa is a mesotrochantin. One end is V-shaped and one of the arms of the V articulates in a distinct mesotrocoila. The other end is truncated and located in the mesocoxacoria. The mesotrochantin is more firmly articulated to the leg than to the thorax and is frequently removed with the leg. The minute sclerite located between the emargination of the mesotrochantin and the mesocoxa is a mesocoxella.

Mesopleuron.—Each lateral third of the ventral aspect is occupied by a mesopleuron. A mesoperitreme is located in the middle of the mesocoria cephalad of each mesopleuron. It is oval in outline and setiferous. The mesoprelabia and mesopostlabia are vertical. The middle of the cephalic margin of the mesoprelabia is

thickened. The quadrangular area occupying the greater part of each mesopleuron is a mesepisternum. Its mesal end is separated externally from a mesocoxacava by the mesosternannum. The cephalic end is transverse and infolded. It is crossed by a distinct hyposternum which is continuous across the mesosternannum and the mesopleuron of the other side. The exposed lateral portion is oblique with a distinct shoulder on the cephalic portion. The lateral portion extends onto the dorsal aspect forming a furrow into which an elytron fits when it is closed. The caudo-mesal portion of the mesepisternum extends dorsad under the caudo-lateral extension of the mesosternannum into the mesocoxacava, where it unites with the mesepimeron and mesopleuradema in the formation of a prominent mesocoxacoila. The exposed part of the mesepimeron is the narrow hem-like area extending along the caudal margin of the mesepisternum. The mesepimeron also extends dorsad as a vertical plate attached to the caudal margin of its exposed surface. The mesal end extends dorsad of the caudo-lateral extension of the mesosternannum and fuses with the mesepisternum and mesopleuradema to form the mesocoxacoila. The lateral portion of this vertical area extends cephalad along the lateral margin of the dorsal part of the mesepisternum and forms a part of the furrow into which the margin of the elytron fits. The mesopleural suture is distinct throughout the length of this furrow except on the mesopleuralifera which is the short broad projection mesad of the shoulder of the mesepisternum. The mesopleurademina is closed. The mesopleuradema is a large thin lamella extending from the mesocoxacoila to the mesopleuralifera. It is fused to the mesopleural suture and with a mesofurca. The area on the cephalic side of the mesopleuralifera, which is bluntly pointed and over which the bifurcate portion of the elytron articulates is the mesoprealifera. Its caudal end is fused with the mesopleuralifera. The mesomedalifera is obsolete. The small disca caudad of the mesopleuralifera and fused to a mesopteralia is the mesopostalifera.

Draw the mesosternum and the dextral mesopleuron and name all the parts.

Draw the ental surface of the mesosternum and the sinistral mesopleuron and name all the parts.

Metasternum.—The large mesal area located caudad of the mesosternannum and forming the caudal half of the mesocoxacava is the metasternum. The metacoxacavae are formed from the infolding of the unacoriae. The metacoxacoriae are short. The metatrochantins and metacoxellae are obsolete. The metacoxae are large and transverse. The metasternoideae are completely fused

with the metepisterna. The exposed part of the metasternum belongs to the metasternannum. The cephalic portion is deeply infolded forming the caudal half of each mesocoxacava. The mesal part of the cephalic portion forms the blunt metacoxal process, which articulates against the mesosternal process. There is a compressed parademe at the cephalic end of the meson of the metasternannum near the mesosternellum. Each cephalo-lateral angle of the portion infolded into a mesocoxacava articulates against the infolded caudo-lateral angle of the mesosternannum. The lateral margins of the metasternannum are strongly convex and divergent caudad. The sutures limiting these margins are the metatrocasutures. The caudal margin, except the mesal process, is transverse. The caudal end of this process is minutely concave and the abdominal coxal process articulates in the concavity. There is a prominent mesal infolding with a lamella extends from near the mesocoxal process to the caudal end of the metasternal process. The transverse infolded lamellate furrow extending across the caudal part of the metasternannum cephalad of the metasternal process is known as the antecoxal suture and the area caudad of this suture as the antecoxal piece. The mesal furrow is a fissure. There are two minute projections with an emargination between them on each side of the caudal end of the mesal fissure. Each of these emarginations is a metafurcina. The metafurcae are fused with the lamella of the antecoxal suture, with each other, and with the lamella of the mesal furrow. They extend cephalad to near the mesocoxacavae. The metasternellum is the minute projection on the lateral side of each mesofurcina. They are connected by a mesal area of membrane and are continuous with the unacoria. The minute projections bearing metafurcinae serve as metasternacoilae.

Metapleuron.—The metapleuron is longer and narrower than the mesopleuron. The metacoria is long, particularly the lateral part, but is concealed by the close apposition of the mesopleura and metapleura. The metaperitreme is not as broad as the mesoperitreme and is located in the metacoria cephalad of the metapleuron. The metaprelabia is similar to the metapostlabia. The exposed portion of the metepisternum, adjacent to the metasternannum, is triangular in outline. Its cephalic, mesal, and caudal margins are hemmed. The cephalic margin is infolded as a small vertical transverse area. The median half of the dorsal margin of this infolded transverse area extends cephalad as a much thinner horizontal area over the mesepisternum. The lateral margin is bent onto the dorsal aspect forming a long narrow area, broadest at its cephalic end. The exposed part of each metepimeron is the suboval area at the

caudal end of a metepisternum. This area is infolded for its entire length and the two surfaces are closely fused forming a plate which projects over the abdomen. The metepimeron also extends onto the dorsal aspect as a triangular area along the lateral margin of the dorsal part of the metepisternum. It is broadest at the caudal end and is fused with the lateral part of the unasternum. The two are separated by a distinct unasuture. The greater part of this dorsal portion of the metepimeron is not strongly chitinized. The metacoxacoila is the small blackish projection at the caudo-mesal end of each metepisternum, beneath a metepimeron. It is formed by a fusion of the adjacent parts of the metepisternum, metepimeron, and metapleuradema. The metapleuralifera is the long slender projection at the cephalo-lateral angle of the dorsal part of each metapleuron. It has a tooth-like projection near the middle of its cephalic margin. The metapleural suture extends cephalo-laterad from the metacoxacoila to the metapleuralifera, across which it can be traced. The metapleurademinae are closed. Each metapleuradema extends cephalad from adjacent to each metacoxacoila as a long slender thread-like tendon into the body-cavity. It also extends as a slight lamella along the metapleural suture onto the metapleuralifera and along the lamella of the unasuture. The long slender transverse sclerite cephalad of the metapleuralifera is the metaprealifera. Its mesal end is expanded into a large stalked disca which folds under the metaperitreme and metepisternum. The small sclerite cephalo-mesad of the tooth-like projection of the caudal margin of the metapleuralifera is the metamedalifera. The suture between it and the metaprealifera is distinct. The oval area located laterad of the metepimeron with a darker band on the mesal or dorsal margin is the metapostalifera. It is modified into a large sessile disca.

Draw the metasternum and the dextral metapleuron and name all the parts.

Draw the ental surface of the metasternum and the sinistral metapleuron and name all the parts.

4. MESONOTUM AND METANOTUM

There is the greatest diversity of opinion as to the presence and extent of the various sclerites of the notum. This is particularly true if a series of representatives of the different orders are examined. There are few, if any, writers who agree on the homology of all the sclerites. The homology of the notal sclerites of all orders is just as easily determined as the homology of the sternal and pleural sclerites if the proper landmarks are used.

The notum reaches its greatest complexity in the wing-bearing

segments, the mesothorax and the metathorax, of wing-bearing individuals. The pronotum is only a dorsal projecting shield and is never subdivided into sclerites homologous with those of the other nota. The mesonotum and metanotum of wingless individuals may contain the same sclerites as the same region of winged individuals, but their form and boundary is never as distinct. In those insects where the mesothorax is greatly enlarged and the mesowings are greatly expanded, the metanotum is usually small and inconspicuous and the metanotal sclerites are always more completely fused. The metanotum is only rarely decidedly larger than the mesonotum. There is a direct correlation between the development of these nota and the presence and the size of their wings.

The broad transverse infoldings of the notum for the attachment of muscles are known as phragmata. They are generally considered as a part of the endoskeleton and are designated as the entonotum. The phragmata are only slightly developed in generalized insects, but are of considerable size in specialized insects. These structures are entirely different in form, origin, and structure from the endoskeleton of the head, sternum, or pleuron, which originates in most cases as invaginations during embryological development. The phragmata are only transverse infoldings of the external cuticle. Their size and complexity are correlated with the specialization of the function of flight. They are very large in the Entopteraria and originate during the prepupal or pupal stage.

Specimens for the study of the mesonotum and metanotum should be cleared in caustic potash and studied in seventy per cent alcohol. They should retain the caudal portion of the pronotum, the cephalic portion of the unatergum, and a small portion of each pleuron. Specimens that have been divided on the meson should be available for comparison and, where the cephalic part of the mesonotum is vertical, there should be specimens of this vertical area.

Praescutum.—The short transverse area at the cephalic end to which the mesocoria is attached (Fig. 9, *pcs*) is the praescutum. It is present as a distinct sclerite only in generalized insects and is also known as the prescutum, protergite, or pretergite.

Pseudalis.—The small sclerite located laterad of the tegula and near the praescutum, of which it is probably a derivative, in the mesothorax of certain orthopterous insects is the pseudalis. Its surface is invaginated to form a short blunt finger-shaped parademe.

Scutum.—The second and largest region of the notum (Fig. 9, *scm*) is the scutum. Its surface is subdivided by suture-like fur-

rows or thickenings into definite areas. The scutum is also known as the dorsum, mesotergite, or ecusson, and in the mesonotum as the dorsolum and in the metanotum as the postdorsolum.

Scutellum.—The third region of the notum (Fig. 9, *sct*) is the scutellum. It usually consists of three parts, a mesal shield-shaped area and a transverse area on each side. The mesal portion generally forms the dorsal wall of a projecting transverse lobe.

Postscutellum.—The fourth region of the notum (Fig. 9, *pts*) is the postscutellum. It is a large prominent area in the mesonotum, generally subdivided by infoldings and ridges or thickenings into several distinct parts, but is usually greatly reduced in the metanotum. The postscutellum in many insects is transversely subhorizontally infolded. The dorsal surface of this infolded area combines with the scutellum and forms the ventral wall of its projecting portion. The ventral surface is always larger than the dorsal and extends from the cephalic margin of the dorsal surface to the metacoria or unacoria. The postscutellum has been considered as wanting by certain authors. It is also known as the costal, cloison costale, subpostdorsum, metaphragma, pseudonotum, postnotum, or acrotergite, and in the metanotum as the tergum or postfroenum.

Phragma.—Each of the transverse infoldings of the ectal surface of a notum for the attachment of muscles is a phragma. The phragmata are always composed of two adjacent, closely appressed, or fused surfaces. These surfaces can usually be separated for their entire length and one of the faces is frequently more strongly chitinized than the other. If the phragma is located between two sclerites and it is the cephalic surface that is strongly chitinized, the phragma appears to belong to the cephalic sclerite; if, however, it is the caudal surface that is strongly chitinized, it appears to belong to the caudal sclerite. The phragmata are parademes in structure and not apodemes.

Prephragma.—The phragma located at the cephalic end of the notum (Fig. 9, *peg*) is the prephragma. It is the most persistent of all the phragmata and is formed by a transverse infolding of the praescutum. In many insects it is so large that the entire praescutum and the adjacent parts of the coria and scutum are infolded. The prephragma is also known as the anterior phragma, in the mesonotum as the prophragma or proterophragma, and in the metanotum as the mesophragma or deutophragma.

Prephragmina.—The transverse ectal opening or thickening marking the entrance to the prephragma (Fig. 9, *pei*) is the prephragmina. It is also known as the anterior notal ridge.

Paraphragma.—The phragma formed from the ental surface of the suture between the scutum and scutellum (Fig. 9, *ppg*) is the paraphragma. It is sometimes fused with the cephalic end of the infolded portion of the postscutellum and, when of any size, extends cephalad.

Paraphragmina.—The transverse ectal opening or thickening marking the entrance to the paraphragma is the paraphragmina. It coincides with the mesal portion of the scuto-scutellar suture.

Postphragma.—The phragma located at the caudal end of the notum or postscutellum (Fig. 9, *ptp*) is the postphragma. It is rarely present. The large metaprephragma of specialized insects has been considered as a mesopostphragma by many writers.

Postphragmina.—The transverse ectal opening or thickening marking the entrance to the postphragma is the postphragmina.

Tegula.—The small convex setiferous pad-like area (Fig. 9, *tg*) located in the notacoria near the proximal end of the cephalic margin of each wing is a tegula. They are the convex-concave disk-like structures which cover the proximal ends of the mesowings of many specialized insects. The tegulae should not be confused with the patagia, structures of the pronotum, or with the alula and calyptera, lobes continuous with the anal region of the wing of some flies and beetles. They are also known as squamulae, pterygoda, epaulettes, patagiae, hypopterae, cuillera, tegular plates, or paraptera.

Alaria.—Each lateral margin of the notum is provided with more or less distinct projections against which the wing articulates. These projections are the alariae. They are constant in position in all insects and are useful landmarks for determining the homology of the notal sclerites. They are also known as the notal wing processes.

Cephalaria.—The alaria present on each lateral margin of the praescutum cephalad of the prephragma (Fig. 9, *cpl*) is the cephalaria. It is present only in generalized insects.

Medalaria.—The alaria present on the cephalic part of each lateral margin of the scutum (Fig. 9, *mdl*) is a medalaria. It is the most important of the alariae and is always present in winged insects. Each medalaria frequently consists in generalized insects of two divaricating projections which form a letter V. It is also known as the anterior notal process or anterior notal wing process.

Caudalaria.—The alaria present on the caudal part of each lateral margin of the scutum (Fig. 9, *cal*) is the caudalaria. It is sometimes only a slight indentation, adjacent to the medalaria in specialized insects and distant from the medalaria in generalized

insects, where it is also known as the posterior notal process or posterior notal wing process.

Scutalaria.—Each lateral end of the scutellum is frequently extended as a blunt projection (Fig. 9, *scl*) into the notarotaxis. This projection is the scutalaria. It is also known in specialized insects as the posterior notal wing process.

Spiralis.—The thickened fold or cord attached to the proximal part of the caudal margin of each wing (Fig. 9, *spa*) is a spiralis. It extends along the caudal margin of each lateral portion of the scutellum and is frequently transversely striated like a trachea. The spirales are sometimes continuous and are excellent landmarks for determining the position of the caudal margin of the scutellum. Each spiralis is also known as an auxillary cord, ligamento, or spring-vein.

Cephacoria.—The indentation (Fig. 9, *cpc*) continuous with the notarotaxis, sometimes of considerable size, and located between the cephalaria and medalaria, is the cephacoria.

Medacoria.—The indentation (Fig. 9, *mec*) continuous with the notarotaxis, located between the medalaria and caudalaria, is the medacoria. It is also known as the lateral notal emargination.

Caudacoria.—The indentation continuous with the notarotaxis (Fig. 9, *cac*), located between the caudalaria and scutalaria, is the caudacoria. It is frequently, particularly in specialized insects, a prominent feature of the notum and separates the lateral portions of the scutellum from the scutum.

Scutarea.—The mesonotum of certain hemipterous insects contains a triangular elevation against which the proximal part of the caudal margin of the mesowings is folded. This elevation is the scutarea. It is universally designated as the scutellum. This designation can not be used as it is only an area and not a sclerite. The scutarea is formed in great part from the mesoscutum together with small portions of the mesoscutellum and mesopostscutellum.

Scutulis.—The scutellum consists of three portions, (Fig. 9, *scu*), a mesal shield-shaped portion and a short, flat or subvertical, lateral portion on each side. The mesal portion is the scutulis. In the Coleoptera it is a large area distinct from but usually fused in great part to the dorsal surface of the mesoscutum. Its exposed caudal portion, against which the mesowings or elytra are folded, is triangular. The lateral portions (Fig. 9, *pst*) of the scutellum, if a name is necessary, may be known as the parascutules.

Parapsides.—The two furrows on the mesoscutum of many specialized insects (Fig. 9, *pps*) which frequently converge caudad

forming a V are the parapsides. They are also known as the parapsidial furrows or notauli.

Prenota.—The mesal area of the cephalic part of the mesoscutum bounded by the parapsides (Fig. 9, *pnt*) is the prenota. It is frequently triangular and is also known as the frontal lobe or praescutum.

Paranota.—Each lateral area of the mesoscutum bounded by a parapsidis and the lateral margin of the mesoscutum (Fig. 9, *pna*) is a paranota. The caudal ends of the parapsides frequently unite and the paranotae are continuous on the meson or the caudal ends of the parapsides are obsolete and the prenota and the paranotae are continuous. Each paranota is also known as a lateral lobe, parapsidis, scapula, or juxtascutellum.

Pleuranota.—Each cephalo-lateral portion of the mesoscutum is developed into a transverse area. This area is located between the mesepisterna and the mesocoria and is known as the pleuranota.

Notoptera.—The caudal part of the metascutum of the Coleoptera is provided with a pair of parallel ridges or thickenings, the notopterae.

Notopteraria.—The portion of the metascutum bounded by the notoptera is the notopteraria. It forms with each notoptera a concavity in which the proximo-caudal portions of the meso-wings or elytra are secured. The notopteraria is also known as the median notal groove.

Transversa.—The pronotum in the heteropterous Hemiptera forms a notalia which projects over the mesonotum. The notalia extends to a furrow or thickening of the mesoscutum at the cephalic end of the scutarea, the transversa. It is formed by an infolding of the ectal surface and its lateral ends do not reach the lateral margins of the mesoscutum. The transversa has hitherto been considered as the primary suture separating the mesoscutum and mesoscutellum. It is not a suture.

Frenum.—The deep furrow along each lateral margin of the scutulis in certain Hemiptera, converging caudad, is a frenum. It is formed from the mesoscutum and mesoscutellum.

Axilla.—The convex vertical or subvertical area of the scutum (Fig. 9, *ax*) located between the medacoria and the caudacoria is the axilla. It is limited to the mesoscutum in specialized insects.

Latuscula.—The small longitudinal area of the mesoscutum of Diptera adjacent to the cephalic part of the mesonotacoria is the latuscula. Its dorsal boundary is an infolded lamellate furrow, which is apparently the notopleural or dorsopleural suture of dipterologists.

Suprascutella.—The postscutellum, particularly in the mesothorax, is transversely infolded in many insects forming two surfaces which usually project cephalad under the scutellum. The dorsal surface of this infolded area is the suprascutella. It is the so-called postscutellum of hymenopterists.

Subscutella.—The ventral surface of the transversely infolded postscutellum (Fig. 9, *sub*) is the subscutella. It is usually subdivided into three regions in the mesonotum and its caudal margin is frequently continuous with a subchitinized metacoria.

Mesascutella.—The mesal area of the mesosubscutella (Fig. 9, *msc*) is the mesascutella. Its lateral ends are limited by distinct infolded longitudinal thickenings.

Parascutella.—Each lateral portion (Fig. 9, *psl*) of the mesosubscutella, extending between the mesascutella and an epimeron, is a parascutella. It sometimes extends onto the pleuron and forms a distinct area, as in the Diptera, between the mesepimeron and the metepisternum.

Durascutella.—The infolded longitudinal thickening on each side separating the mesascutella from a parascutella (Fig. 9, *dur*) is a durascutella. They are frequently important landmarks in identifying the position of the subscutella.

Tergonta.—Each caudo-lateral angle of the metapostscutellum frequently forms a prominent projection which articulates against or is fused with the unatergum. These projections are the tergontae.

Alula.—The small lobe attached to the proximal end of the anal margin of the wing is the alula. It is attached to the ventral surface of the mesowing or elytra of certain Coleoptera and is also known as the posterior lobe or alulet in the Diptera or as the anallappen, axillary membrane. The free margin of the alula is bounded by the spiralis.

Calyptera.—There are two prominent lobes located proximad of the alula in certain of the specialized Diptera, the calyptera. Their free margin is bounded by the spiralis and they are developed from the mesonotacoria or rotaxis. The proximal lobe is the proxacalypteron and the distal is the distacalypteron. The alula and the calyptera are usually folded together, the alula is the dorsal, the distacalypteran the intermediate, and the proxacalypteron the ventral lobe. The calyptera are also known as the tegulae, squamulae, or alula, the distacalypteron as the antosquamo, squama, alaria, or antitegula, and the proxacalypteron as the squama, squama thoracicalis, tegula, calypteron.

BLATTA ORIENTALIS.—The notum is limited to the dorsal aspect.

It is restricted by the articulation of the wings. The following description is based upon the male. The female is more generalized, most of the parts can be identified, but the alariae are wanting.

Mesonotum.—The mesocoria is long and deeply infolded under the notalis. The short transverse thickened area along the cephalic margin is the mesopraescutum. The furrow on its ectal surface is the mesoprephragmina. It is fused on the meson and closed. The mesoprephragma is only a convex thickening, not lamellate. The small brownish area at each lateral end of the mesoprephragmina with its cephalic end produced as a parademe is a pseudalis. The mesopraescutum is convex caudad of each pseudalis and extends laterad as a long bluntly pointed horizontal projection, the mesocephalaria. The oval setiferous area in the angle between each pseudalis and a mesocephalaria is a mesotegula. The large area extending from the mesopraescutum to the transverse thickening near the caudal margin, which is concave on the cephalic side, is the mesoscutum. The faint line extending through this thickening is the suture marking the caudal extent of the mesoscutum. There are two converging thickenings extend cephalad from this transverse thickening which terminate in a fine linear ridge. The ridge marks the distance the notalia overlaps the mesonotum. The distinct indentation caudad of the mesocephalaria is a mesocephacoria. The rounded shoulder to which a large Y-shaped mesopteralia is firmly attached, forming the caudal boundary of the mesocephacoria, is the mesomedalaria. The large angular indentation caudad of the mesomedalaria is the mesomedacoria. It is limited at its caudal end by the angular caudo-lateral portion of the mesoscutum, the mesocaudalaria. The narrow deep indentation caudad of the mesocaudalaria is the mesocaudacoria. The free projecting plate-like area along the caudal margin of the mesoscutum is the mesoscutellum. The mesal third, not separated as a mesoscutulis, is longer than each lateral third. The lateral end of each lateral portion is membranous and continuous with the mesocaudacoria and mesonotacoria. The mesospiralis is not distinct. The mesopostscutellum is in great part covered by the mesoscutellum. The mesosubscutella is larger, not so strongly chitinized, and continuous with the metacoria. It contains two large distinct subtriangular durascutellae. Their cephalic ends are connected by a slender brownish band. The parascutellae are continuous with the mesonotocoria. The ental surface of the mesal portion of the cephalic end of the mesopostscutellum is fused with the slightly developed mesoparaphragma.

Metanotum.—The metacoria is short. The short transverse

furrowed area adjacent to the metacoria is the metapraescutum. Each durascutella is fused to its cephalic margin. The furrow forms a distinct metaprephragmina. The metaprephragma is not lamellate, but contains a small projection just laterad of the fusion of each durascutella. The pseudalis is wanting. Each caudo-lateral angle of the metapraescutum forms a large blunt metacephalaria. The transverse setiferous area cephalad of each metacephalaria is a metategula. The large area caudad of the metapraescutum is the metascutum. The caudal limit of the mesal portion of the metascutum is a distinct transverse thickening. There are converging thickenings extend cephalad as in the mesonotum and each is irregularly thickened near the middle of its lateral margin. The metacephacoria is narrow and deep. It is limited on the caudal side by a blunt shoulder, the metamedalaria, against which a large metapteralia articulates. The metamedacoria is long and deep. Its caudal limit is the angular projection forming the caudo-lateral portion of the metascutum, the metacaudalaria. The deep angular indentation caudad of the metacaudalaria is the metacaudacoria. The transverse area along the caudal margin of the metascutum and metacaudacoria is the metascutellum. The mesal portion, not forming a metascutulis, is a broad lobe and its caudal margin is transverse with a minute mesal projection. Each lateral portion of the metascutellum is a subcrescentic brownish projection forming a metascutalaria. The metaspiralis is not distinct. The metapostscutellum is in great part concealed by the metascutellum. The metasuprascutella is similar in size and shape to the metasubscutella. The metasubscutella is submembranous. The tergontae are brownish subtriangular areas extending to the short unacoria. The unapredorplica is only slightly developed. The ental surface of the mesal portion of the cephalic end of the metapostscutellum is fused to the slightly developed metaparaphragma.

Draw the mesonotum and the metanotum and name all the parts.

Draw the ental surface of the mesonotum and metanotum and name all the parts.

Melanoplus Differentialis.—The boundaries of the sclerites are not well marked. The surface is convex and the lateral portions are curved ventrad. The alariae are wanting.

Mesonotum.—The mesonotum is covered for the most part by the notalia. The mesocoria is long. The mesoprephragmina is open on each lateral third and is fused on the mesal third and closed. The mesoprephragma is lamellate on each lateral third, the lamellae are connected by a mesal convex thickened bar. The narrow transverse area cephalad of the mesoprephragmina belongs to the meso-

praescutum. Each lateral portion extends onto the lateral aspect as a pointed projection upon which the cephalo-dorsal portion of a mesoprealifera rests. The suture between the mesopraescutum and the mesoscutum is invaginated into the mesoprephragma. There is a broad depression or furrow extends caudo-laterad from near each lateral end of the mesal closed portion of the mesoprephragmina to a minute indentation in the lateral margin of the mesonotum. This indentation is the mesocephacoria. The convex shoulder cephalo-laterad of the mesocephacoria belongs to the mesopraescutum. The caudo-lateral projection of this shoulder is a mesocephalaria. The small convex setiferous area located between the mesopraescutum and each mesoprealifera is a mesotegula. The large convex area caudad of the mesopraescutum and occupying the greater part of the mesonotum is the mesoscutum. The mesal part of the caudal portion is a convex shield-shaped area, sometimes incorrectly designated as the mesoscutellum. The V-shaped projection caudad of each mesocephacoria is a mesomedalaria. The mesomedacoria is shallow. The slight indentation in each lateral margin of the mesoscutum in which a mesopteralia is articulated is a mesocaudalaria. The irregular indentation forming the caudal boundary of each convex lateral margin of the mesoscutum is the mesocaudacoria. The furrow extending laterad from the mesocaudacoria around the caudal margin of the shield-shaped area is the suture separating the mesoscutum and mesoscutellum. The setiferous area caudad of this suture and of the mesoscutum is the mesoscutellum. It is a transverse free projecting plate. The mesoscutulis is not defined. Each caudo-lateral angle is produced into a mesoscutalaria, to which the mesospiralis is attached and can be traced along the caudal margin of the mesoscutellum. The mesopostscutellum is concealed by the mesoscutellum. The mesosuprascutella is subequal in size to the transverse part of the mesoscutellum.. The mesosubscutella is a very short area continuous with the long metacoria. The durascutellae are wanting. The ental surface of the cephalic end of the mesopostscutellum is fused with the mesoparaphragma.

Metanotum.—The metaprephragmina is covered by the mesoscutellum. It is the prominent transverse furrow at the cephalic end of the metanotum. The metaprephragma is a large lamella, which is roundly emarginate on the meson. Each cephalo-lateral angle extends cephalad as a finger-shaped projection under each mesoscutalaria and serves as a point of articulation for a mesopteralia, the mesonavicula, located near the mesocaudacoria. This projection of the metaprephragma is the phragmalaria. The brownish area along the cephalic margin of the metaprephragmina

is a part of the metapraescutum. Each lateral end of this area is fused with the mesopostscutellum. There is a broad depression or furrow extends caudo-laterad from each lateral end of the closed part of the metaprephragmina to the lateral margin of the metanotum. This line marks the position of each lateral portion of the suture between the metapraescutum and the metascutum. The mesal portion is concealed in the metaprephragma. The portion of the metapraescutum cephalo-laterad of this suture on each side is a flat subtriangular area with a slight projection on the caudal part of its lateral margin, the metacephalaria. The indentation caudad of the metacephalaria is the metamedacoria. The subvertical area with a convex lateral margin is a part of the metascutum, a metaxilla. The slight notch in its caudo-lateral portion is the metacaudalaria and the indentation caudad of it is the metacaudacoria. The large area caudad of the metapraescutum with a mesal shield-shaped area on the caudal portion is the metascutum. The furrow curving cephalo-mesad from each metacaudacoria to the shield-shaped area and thence around its caudal margin is the suture separating the metascutum and the area caudad of it, the metascutellum. The mesal third of this latter sclerite is longest and coarsely punctured. The metascutulis is not defined. Each lateral third is not so strongly chitinized and projects as a metascutalaria to the caudal margin of which the indistinct metaspiralis is attached. The metapostscutellum is long. The metasuprascutella is a short transverse area. The metasubscutella is about three times the length of the metasuprascutella and extends to the unasuture, which is deeply infolded as a prominent unapredorplica. Each lateral portion of the metasubscutella extends onto the lateral aspect between a metepimeron and the unatergum, where the unasuture is obsolete. The mesal part of the cephalic margin of the metapostscutellum is fused with the metaparaphragma.

Draw the mesonotum and metanotum and name all the parts.

Draw the ental surface of the mesonotum and metanotum and name all the parts.

5. PTERALIAE

The wing-sclerites or pteraliae are the chitinized areas of the rotaxis located between the proximal portion of the wing and the thorax. The shape and articulation of the pteraliae, which are the points of articulation and rotation between the proximal ends of the veins and the projections of the notum and pleuron, are correlated with the characteristic type of flight which is also correlated with the shape of the wing and the arrangement of the veins.

The chitinized areas of the rotaxis are extremely variable in number and shape. There are three classes of chitinized areas or pteraliae: the duritae, the venellae, and the funditae. The duritae are the distinctly separated areas or sclerites that articulate against the projections of the pleuron and notum, the aliferae and alariae. They are few in number, constant in position, and articulate against prominent projections, the venellae, which are modifications of the proximal ends of the veins. There are also distinct sclerites, the funditae, which are formed from thickenings of the membrane located between the venellae. The duritae, the funditae, which are sporadic in their presence, and the venellae are here included as pteraliae. The term pteraliae as generally applied is limited to the duritae.

While the pteraliae are generally omitted from discussions of the anatomy of the thorax, yet from their function and their influence upon the shape and size of the alariae and aliferae, they deserve consideration in a complete account of the external anatomy of insects. It is very difficult from their position within folds of flexible membrane and their great irregularity in form to describe the pteraliae so that they can be identified from their form alone, because this varies with each angle from which they are observed. Recourse has consequently been had to their articulation. In the use of the terms indicating the cardinal directions, the pteraliae have been described as if the wing were held horizontal and at right angles to the body. The most important of the pteraliae are located in the notarotaxis and, unless otherwise indicated, the descriptions begin with this surface.

Preparations for the study of the pteraliae should include a portion of the pleuron, a portion of the notum, and the proximal half of the wing. They should be thoroughly cleaned so that the pteraliae can be examined not only from the ectal surface but from the cavity of the rotaxis.

DURITAE.—The independent pteraliae interposed between the ends of the veins, the venellae, and the alariae are the duritae.

Sigmoidea.—The sigmoidea (Fig. 9, *sig*) extends cephalo-caudad and usually articulates against the medalaria and caudalaria. It is confined to the notarotaxis and is also known as the sigmoide, parapteron, dens, humerus, vordere and mittlere Tergalplatten, and first axillary; in the mesowings as the grand humeral or preepauliere and in the metawing as the scutellarire or axillary anterieure.

Submedia.—The submedia articulates closely against the distal margin of the sigmoidea. It is also associated with the radialis and

terminalia. In the pleurotaxis it articulates against the pleuralifera, postalifera, and usually the terminalia. The submedia is also known as the submedian, unguiculus, Mittlegelenkplatte, omoplate, and second axillary; in the mesowing as the petit humeral or epauliere anterieure and in the metawing as the diademal or second axillaire.

Terminalia.—The terminalia is located caudad of the submedia, articulates against the scutalaria, submedia, analis, and serves for the attachment of the muscles which fold the anal portion of the wing. In the pleurotaxis the terminalia articulates against the postalifera and usually the submedia. It is also known as the terminal, metapterygium, deltoid, mesoptera, Analwurzelplatte, and hintere Analgelenkplatte, onguiculus, or third axillary; in the mesowing as the petit cubital or epauliere posterieure and in the metawing as the fourchu or quatrieme axillaire.

Navicula.—The navicula is located in the notarotaxis caudad of the terminalia and articulates against the phragmalaria. It is only rarely present and is also known as the naviculaire, hintere Tergalplatte, or fourth axillary.

Venellae.—The venellae are unseparated modifications of the proximal portions of the veins. They are named from the veins of which they are projections, as costalis, radialis, and analis.

Costalis.—The costalis is located on the cephalic margin of the rotaxis, extends into both notarotaxis and pleurotaxis, and usually articulates against the cephalaria or medalaria and the prealifera and pleuralifera.

Radialis.—The radialis is the largest and one of the most important pteralia of the rotaxis. It is formed by a fusion of the proximal portions of three wing-veins, the subcosta, the radius, and the media, and has been named for the largest vein, the radius. It is closely associated with the costalis, sigmoidea, and submedia, and articulates against the medalaria, prealifera, and pleuralifera.

Analis.—The analis is a projection, variable in size, formed from the cubital and anal veins. It is closely associated with the terminalia and has been considered by some writers as a part of the terminalia.

Funditae.—The funditae are the chitinized areas located between the venellae and the duritae. They are named from the veins with which they are associated, as costallae, mediellae, or anellae. The mediella is the most persistent. It is closely associated with the submedia, of which it may be a part, and is generally subdivided into parts by a furrow or indentation.

Blatta Orientalis.—The pteraliae are distinct and easily

identified. The descriptions are based upon the wings of the male.

Mesopteraliae.—The subtriangular area at the proximal end of the cephalic margin of the mesowing distad of the mesotegula is the mesocostalis. The stout projection caudad of the mesocostalis is the mesoradialis. It is located in the mesonotarotaxis and articulates against the mesoprealifera and mesopleuralifera. The distal end is fused with the mesowing. The twisted triradiate sclerite with its broadest end articulating against the mesomedalaria is the mesosigmoidea. Its cephalic end is interposed between the mesocephalaria and the mesoradialis. The distal margin is concave. The sclerite articulating in this concavity is the mesosubmedia. Its cephalo-distal end is fused with the mesoradialis. It is also fused with the thinner folded area caudad of it, the mesomediella. There is a lobe of the mesowing articulates against the caudo-lateral portion of the dorsal surface of the mesosubmedia. Its caudo-proximal angle is prolonged and fused with the mesoterminalia. This area consists of a distal and a proximal portion. The distal portion is a subquadrangular area located in the mesonotarotaxis and separated from the mesowing and the proximal portion of the mesoterminalia by longitudinal folds. The proximal portion of the mesoterminalia near its fusion with the mesosubmedia divides into two parts. One part extends through the mesonotarotaxis as a large projection and articulates against the mesopostalifera. The mesosubmedia extends caudo-ventrad as a slender thickened projection and articulates against the mesopleuralifera. Its caudal end articulates in a distinct acetabulum in the mesoterminalia near the mesopostalifera. The small subtriangular subvertical area located in the mesonotarotaxis between the mesosubmedia and the proximal part of the mesoterminalia is a fold of the mesoterminalia. The broad brownish band caudad of the mesoterminalia and associated with the mesocaudalaria is a mesanella. The mesonavicula is wanting.

Draw the mesonotarotaxis and name all the parts.
Draw the mesopleurotaxis and name all the parts.

Metapteraliae.—The small subtriangular area on the proximal part of the cephalic margin of the metawing is the metacostalis. It is distinctly separated from the blunt projection, the metaradialis, which articulates against the metacephalaria. The metacostalis and metaradialis are fused in the metapleurotaxis and articulate against the metacephalaria and the metaprealifera. The sclerite articulating against the metamedalaria is the metasigmoida. Its cephalic portion is a slender clavate projection, the cephalic end of which is interposed between the metacephalaria and the metaradialis. The caudal portion is a subtriangular area. The distal

margin is broadly concave. The sclerite articulating against this concavity is the metasubmedia. The cephalic end of the metasubmedia is fused with the slight thickening along the caudal margin of the metaradialis. The metasubmedia is continuous with the subtriangular folded area located distad of the metasubmedia, the metamediella. The metasubmedia terminates in the metanotarotaxis near the caudo-distal angle of the sigmoidea as a pointed projection. The convex area articulating against this projection is a part of the metaterminalia, which extends caudo-proximad and articulates against the metacaudalaria. The distal portion of the metaterminalia is deeply infolded and fused with the caudal end of the metasubmedia and the anal portion of the wing. The metasubmedia extends into the metapleurotaxis, the cephalic portion articulates against the metaprealifera and the metapleuralifera and the caudal portion, which is a long slender projection, articulates against the metapostalifera. The caudal end of the metaterminalia adjacent to the metacaudalaria is bent into the cavity of the metarotaxis, forming a short blunt projection which articulates against the metapostalifera. The brownish area located near the metascutalaria is a metanella. The metanavicula is wanting.

Draw the metanotarotaxis and name all the parts.

Draw the metapleurotaxis and name all the parts.

Melanoplus Differentialis.—The rotaxis is limited in extent. The pteraliae are closely united and articulated to the alariae and aliferae.

Mesopteraliae.—The cephalo-proximal portion of the mesowing is a large membranous lobe with an indistinct elongate area, the mesocostalis, in the caudal part of the membrane distad of the mesotegula. The black stout hooked thickening caudad of the mesocostalis is the mesoradialis. It articulates in the concave lateral end of the mesocephalaria and against the cephalic projection of the mesomedalaria. The hook is directed caudad and articulates against the cephalic part of the mesopleuralifera. There is a projection near the middle of the ventral surface of the mesoradialis which articulates in the concavity of the mesomedalifera. The sclerite which articulates between the two projections of the mesomedalaria is the mesosigmoidea. The cephalic portion is a slender clavate hook which rests upon the hook of the mesoradialis and articulates against the cephalic projection of the mesomedalaria. The caudal portion is triangular and the caudo-proximal angle is pointed and rests upon the mesosubmedia, which is the sclerite articulating against the distal margin of the hooked portion of the mesosigmoidea and the hook of the mesoradialis. The ental portion

of the proximal margin of the mesosubmedia is thickened and articulates against the ental surface of the dorsal end of the mesopleuralifera. The caudal end is prolonged into the mesopleurotaxis and articulates in the large emargination of the dorsal margin of the mesopostalifera. The poorly defined thickening appearing to be a part of a vein along the caudal margin of the mesoradialis to which the cephalo-distal portion of the mesosubmedia is fused is a part of the mesoradialis. The much thinner area distad of the mesosubmedia is the mesomediella. It is fused to the mesoradialis and separated from the mesosubmedia by a slight fold. The pointed caudal portion of the mesosubmedia is concealed by a fold of membrane. It is fused with the transverse area, the mesoterminalia, extending proximad from the anal region of the wing. The ental surface of the proximal end of the mesoterminalia articulates against the caudal end of the mesopostalifera. The small V-shaped sclerite located in the mesonotarotaxis and fused to the cephalic end of the phragmalaria is the mesonavicula. It is interposed between the mesoscutellum and mesoterminalia.

Draw the mesonotarotaxis and name all the parts.
Draw the mesopleurotaxis and name all the parts.

Metapteraliae.—The proximal portion of the cephalic margin of the metawing is membranous. The metacostalis is wanting as a chitinized area in the metarotaxis. The stout projection forming the caudal boundary of this membrane with a blunt hook at the proximal end is the metaradialis. It articulates against the metacephalaria, the cephalic projection of the metamedalaria, and the end of the metapleuralifera. The metasigmoidea is subvertical and concealed unless the metarotaxis is flattened. The cephalic end is emarginate and the cephalo-distal angle is prolonged and articulates against the cephalic projection of the metamedalaria. The caudo-proximal angle is prolonged and articulates against the lateral margin of the metaxilla. The sclerite articulating against the metasigmoidea and normally concealing it is the metasubmedia. Its cephalo-proximal end is prolonged and hooked. It articulates against the cephalic projection of the metamedalaria instead of against the metasigmoidea. The cephalic end articulates against the hook of the metaradialis. The cephalo-distal angle is fused with a slightly thinner portion of the metaradialis. The thin area distad of the metasubmedia is the metamediella. The distal margin of the metasubmedia extends into the metapleurotaxis as a distinct thickening which articulates against the oblique side of the metapleuralifera. The caudal portion of the metasubmedia is notched and concealed by a membranous fold of the metanotarotaxis. This

fold is supported by a convex area which is a part of the thickening fused with the ventral portion of the metamediella, the metaterminalia. Its proximal end articulates against the short slender sclerite articulating against the metacaudalaria, the metanavicula. The metaterminalia extends into the metapleurotaxis and articulates against the caudal end of the metapostalifera.

Draw the metanotarotaxis and name all the parts.
Draw the metapleurotaxis and name all the parts.

CHAPTER V

ABDOMEN

The abdomen is the third region of the body. It consists of a series of consecutive segments, the most of which are similar but none of which bear appendages for locomotion. The four caudal segments may bear appendages. They are derived from embryonic abdominal appendages.

A typical abdominal segment consists of a dorsal transverse plate or tergum and a ventral transverse plate or sternum. These plates are joined on each lateral aspect by a more or less broad area of membrane or coria, the latacoria. This coria in generalized insects contains one or more small sclerites, the latallae. The cephalic latalla of each side of each segment usually bears a spiracle. The transverse coria between the segments of the abdomen, the segmacoriae, except sometimes between the modified cephalic or caudal segments, is usually distinct and when wanting is generally represented by a suture. The flexibility of the latacoriae and segmacoriae makes possible the alternate expansion and contraction of the abdomen which takes place during respiration. It also makes possible the marked dorsal, ventral, and lateral flexure of the abdomen which is not only characteristic of this region but is essential in the life of the insect.

While the abdominal segments appear from a cursory examination to be similar, a critical study will show that the segments at the cephalic end and at the caudal end are very different from the intermediate segments. In certain generalized species the division of the ventral plate or sternum into median and lateral fields can be identified in the first or the first and second abdominal segments. With specialization the cephalic abdominal segments are modified through the change in form of the adjacent parts of the metathorax which has been transformed through the bearing of wings and legs. The first abdominal segment and frequently the first and second segments are much smaller than the others. The sternum of the first segment is frequently wanting while in most Hymenoptera the tergum of the first segment together with its spiracles are combined with the metanotum and is known as a propodeum. The segments at the caudal end of the abdomen have

been altered through their bearing the external opening of the digestive system, the external opening of the reproductive organs, and the appendages associated with copulation and ovoposition.

The external form of the abdomen in the male and female, except for a difference in size, may be similar or identical. In such species it is frequently necessary to examine the reproductive organs to determine which individuals are males and which are females. Such individuals as a rule also lack secondary sexual characters. Difference in external form between the two sexes is of more general occurrence among generalized insects, as might be expected. In certain insects where there is a striking similarity in external form, there is frequently found upon dissection the most striking diversity in structure. The caudal segments, which are retracted and concealed in a pocket formed from the segments cephalad of them, are modified and the appendages or structures, which they bear, are modified into clasping organs in the male and into an ovipositor in the female. The organs of copulation and ovoposition are frequently, however, of such size that it is impossible for the insect to retract these structures and they always remain wholly or in great part exposed.

When embryos of successive ages (Fig. 4), particularly those of the time of gastrulation and later, are examined, there appears upon the cephalic segments, following the segmentation of the germ-band, small conical projections. These appear first on the cephalic segments, head and thorax, but others appear in succession until each segment of the germ-band bears a pair of projections, the limb-rudiments or appendages. The total number of pairs of appendages (Fig. 4, *aba*) borne by the embryo is strong evidence as to the total number of segments (Fig. 4, *ab*) present in the body of the ancestors of insects and consequently as to the number of segments present in the abdomen. Investigators disagree as to the number of segments present, some recognize ten, others eleven, or ten and a dorsal plate or telson, and still others eleven segments and a dorsal telson or twelve segments. The telson is of importance as it bears the external opening of the digestive system, the anus. The evidence that there are at least eleven segments and a telson has not been confirmed. In the honey-bee Nelson shows that the dorsal hypodermis is completed a short time prior to hatching and that only the sternal part of the eleventh segment is present at hatching. If the eleventh tergum can not be identified at this time, the twelfth segment, which is represented by a tergum, can not be identified.

Another factor of equal value with the limb-rudiments in

determining the number of segments existing in the body or in the abdomen of a given species, is the number of neuromeres (Fig. 4, C, I, *nv*) present, the future ganglia of the nervous system. The existence of eleven neuromeres in the abdomen of the embryos of generalized and specialized insects has been shown by several investigators. Nelson in his study of the embryo of the honey-bee (Fig. 4, E-H) shows a neuromere for each of the eleven abdominal segments present. The neuromeres of the tenth and eleventh segments soon fuse into a single homogenous mass which is later fused with the ninth neuromere. During larval development this mass and the ganglia of the eighth segment fuse, so that the caudal ganglion of the larva represents a fusion of the eighth, ninth, tenth, and eleventh neuromeres. This history offers conclusive evidence of the presence of eleven ganglia and, consequently, of at least eleven segments for the abdomen of the larva of the honey-bee.

The number of pairs of limb-rudiments and the number of neuromeres present in the abdomen not only offer evidence as to the number of segments present in the embryo, but are of great value in indicating the number of segments that should be found in the adult of the same species. Such knowledge is of great importance in recapitulating the anatomical conditions found in the adult.

The limb-rudiments of the abdominal segments of the embryo do not differ in form and structure from those of the head and thorax, except that ordinarily they do not proceed so far in their development and are consequently smaller. The great majority of the abdominal appendages disappear during embryonic development. The pair of appendages of the first abdominal segment in many insect embryos keeps pace in their development and growth with the appendages of the thoracic segments for a time or until they are of considerable size. This development is finally stopped, the appendages are broken down, and all trace of them has disappeared when the insect emerges from the egg.

A different condition is found in the case of the appendages of segments eight, nine, ten, and eleven. The limb-rudiments of these segments are retained unaltered in size or shape in the embryo for a considerable time. They begin to grow toward the close of embryonic development in many insects (Fig. 10) and form appendages that can be identified in many adult insects. The limb-rudiments of the eleventh segment develop into cerci and the appendages of the other three segments develop into gonapophyses, from which are formed the ovipositor of the female and the clasping organs of the male. Certain insect embryologists, while they agree that the cerci are developed from the limb-rudiments of the eleventh

segment, consider the gonapophyses simply as hypodermal outgrowths and not as the derivatives of the limb-rudiments of segments eight, nine, and ten. Wheeler and Dewitz, realizing the necessity for following organs not only through their embryonic stages but also through their later stages, have shown in an unrefutable way by tracing continuously the development of the gonapophyses from the limb-rudiments of the embryo to the appendages of the later stages that they are direct derivatives from the embryonic abdominal appendages. It is a simple matter to trace the appendages of the later nymphal stages into the adult.

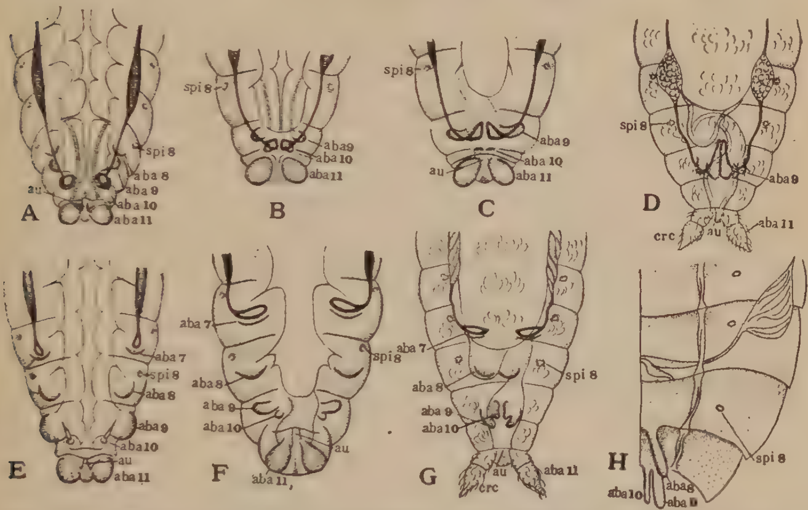

Fig. 10.—Abdominal appendages in Xiphidium (after Wheeler). A-D, male; E-H, female; *aba 8-11*, abdominal appendages; *spi 8*, eighth spiracle; *au*, anus; *crc*, cercus.

The evidence is conclusive, so far as generalized insects of the Exopteraria (Fig. 10) are concerned, as to the homology of the appendages of the caudal end of the abdomen. The problem is a more difficult one in the Entopteraria, because the adult condition is preceded by a larva that in most cases does not bear abdominal appendages on these segments. Many larvae bear appendages (Fig. 4, I, *aba*) on other abdominal segments, the so-called "prolegs," uropods, or larvapods, which are also direct derivatives from the limb-rudiments of the embryo. Several observers have shown that in the case of the gonapophyses and cerci, these appendages are derived from imaginal buds which can be identified in the larva. These buds are found in segments, eight, nine, and ten and are considered as homodynamous with the limb-rudiments of these

segments found in the embryos and nymphs of the Exopteraria.

In the case of the development of the female gonapophyses (Fig. 10, E-H, *aba*) of Xiphidium, Wheeler has shown that the appendages of segments eight, nine, and ten can be traced to the nymphal stages, thus establishing not only the homology of the parts of the ovipositor but its origin in the females of this genus from the abdominal appendages of the embryo. This is such a fundamental condition that it may be assumed that the same condition holds for all the females of the Exopteraria. The young embryos of the male (Fig. 10, A-D, *aba*) of Xiphidium also show appendages on segments eight, nine, and ten. The appendages of the eighth segment disappear when the appendages of the segments cephalad of the eighth disappear. The appendages of the ninth segment persist and are found in young nymphs, while the appendages of the tenth segment although they persist longer than those of the eighth, disappear before embryological development is completed. This leaves only one pair of appendages, the ninth, that may constitute a part of the genitalia of the male. In the cockroach these appendages form the styli and all the accessory organs of copulation are derived from the sternum of the tenth segment. It is believed that this condition holds for all the males of the Exopteraria. The stylets are not of general occurrence in this superorder and the so-called stylets of the Entopteraria are undoubtedly not homologous with those of the Exopteraria. The appendages of the eleventh segment produce the cerci.

The abdomen of the larvae of certain hymenopterous insects contains, as shown by Bugnion and others, three pairs of imaginal discs. These are clearly located in segments eight, nine, and ten, and should represent the centers from which the ovipositor and clasping organs are developed. Observations are lacking to show the sex of these larvae. The derivatives from these three segments in the adult females of Hymenoptera are easily identified and evidently the same method of development is followed here as in the Exopteraria. The fate of these appendages in the male has not been determined. Whether there are three pairs of imaginal discs in the male from which the clasping organs are derived or whether they are derived from the sterna as in the Exopteraria is not clear. The cerci are present in both sexes of many generalized Hymenoptera and whether they are derived from one of the pairs of imaginal discs that have been observed, those of the tenth segment, needs to be determined.

The number of segments in the abdomen of adult insects has been variously indicated by systematists and morphologists, nine

to eleven in the Orthoptera, six to eleven in the Coleoptera, seven to eleven in the Hemiptera, nine to ten in the Lepidoptera, ten to thirteen in the Trichoptera, and four to eight in the Diptera. These numbers are in most cases, at least for the smaller numbers, not the number of segments present, but the number of segments exposed. While the number of segments may be fewer than the studies of late embryonic stages would suggest, the smaller number observed and recorded is not due in most cases to the absence of segments but to the telescoping of the caudal end of the abdomen and the concealing within this invagination of segments, which have been disregarded in the counting.

The most useful single set of structures for the identification of the cephalic segments of the abdomen of the adult is the number of pairs of spiracles. The number found in most embryos, where the maximum number of pairs should be expected, is eight, a pair to each of the first eight abdominal segments. Heymons, however, shows nine pairs in the embryo and nymphs of Lepisma, Hiraschler nine in Donacia, while Wheeler figures eleven pairs of tracheal invaginations in Leptinotarsa, "the two last pairs," the tenth and eleventh, "either disappear or form the openings of the sexual ducts." The larva when ready to emerge from the egg has only eight pairs. Immature and adult insects never have more than eight pairs. The spiracles of the first abdominal segment have been suppressed in some species, but they usually persist even though there may be striking modifications in the form of this segment. The spiracles of the eighth abdominal segment and sometimes those of the seventh segment are often lost where the caudal segments are retracted or concealed. Those of the eighth segment are sometimes lost during metamorphosis as in the Lepidoptera, where the full number is present in the larva, a rudimentary eighth is present in the pupa, and the eighth is wanting in the adult.

The caudal portion of the abdomen is generally entirely different in form in the two sexes. The exposed parts in certain species may be identical in form and number of segments exposed or the male may have one more complete segment exposed than the female. Whether there is any external difference or not, when the parts are extruded, usually a great difference is found. The abdomen of the female in most species is much simpler in form than that of the male and usually symmetrical. When certain of the segments become telescoped and completely concealed, forming a genatasinus, these segments are never so completely chitinized as the exposed segments and some of them may consist entirely of coria. When such a condition exists, it is always difficult to deter-

mine what segments are present. The caudal portion of the abdomen is frequently more swollen than the other portions. This is to accommodate the structures for copulation and ovoposition and to make room for the muscles attached to them. These structures are known collectively as the genitalia.

The genitalia comprise the appendages of the eighth, ninth, and tenth segments. They are also known as the gonapophyses but the former term includes the structures frequently associated with the gonapophyses, modifications of the tergum and sternum or both, which are modified into clasping or guiding structures. Sometimes these modifications are large and prominent structures while the gonapophyses are small and inconspicuous or completely wanting. Ordinarily the proximal parts of the genitalia are retracted and frequently all the parts are concealed. They can always be easily exposed in living specimens or in those that have been treated with caustic potash by gently squeezing the caudal half of the abdomen.

The primary appendages of copulation and ovoposition, while they are morphologically the appendages of segments eight, nine, and ten, are rarely, except in generalized insects attached to their proper segments in the adult. There has arisen in addition to the modification in form for their special function, a necessity for the close apposition of the proximal parts of the various appendages. There consequently takes place during embryonic life a migration from their primitive position to a different one during late embryonic development. This migration is usually completed during postembryonic development. The movement has proceeded so far in some species that all three pairs of appendages are located caudad of the ninth sternum. As a result of so much migration there are usually more of the terga exposed than of the sterna and the terga ordinarily undergo much less modification.

The genitalia of the female are ordinarily less modified than those of the male and in the case of those females that drop their eggs promiscuously or attach them to the surface of the host, the genitalia may be inconspicuous or entirely wanting. Where stout structures for digging the soil or long slender borers for piercing the bodies of other insects or other animals or for piercing the leaves or stems of plants or the trunks of trees, the genitalia are transformed into organs for ovoposition and the opening of the vagina, the vulva, is always closely associated with their proximal ends. It is in such insects that there is found the greatest amount of migration of the appendages constituting the genitalia.

The spermatheca has a different external opening from the

vagina in some species but it normally opens into the dorsal side of the vagina. Many insects have a pouch for excreting a substance for covering their eggs, for forming an ootheca, or for gluing or fastening the eggs to the host, a collaterial gland and its duct. This gland may empty into the vagina, the usual condition, or it may have an independent external opening. The vagina and the tubes connecting with it, the spermatheca, and the duct of the collaterial gland or all the tubes connecting with the exterior, are lined with cuticle and can be identified in specimens that have been treated with caustic potash. Since the external openings of the tubes are often difficult to locate, the presence of these cuticular tubes is often of the greatest value in determining the exact position of their openings.

In the male the genitalia are modified into arms for clasping the body of the female during copulation. They are usually strongly chitinized and in many insects are complicated in form and may be asymmetrical. The condition of the genitalia in the female offers no indicatiou as to their condition in the male. Where they are highly developed in the female, they may be practically wanting in the male or where they are almost or completely wanting in the female, they may be highly developed in the male. The aedeagus is frequently a strongly chitinized tube through which the lumen of the ejaculatory duct extends with an external opening, the meatus, at or near the end of the aedeagus. The lumen of the ejaculatory duct like that of the vagina is lined with cuticle and this fact is often of great value in locating the position of the meatus. The aedeagus can frequently be extruded or retracted and when the other parts are concealed, it may have its distal end exposed. The appendages are modified into clasping organs or claspers, as they are ordinarily called, but in most cases the claspers are formed almost wholly from extensions of parts of the sterna, often the decasternum alone.

The variation in the form of the claspers and aedeagus of the male has been much used by systematists in defining species. Certain writers even claim that they form the best structures for determining the phylogeny of insects as a whole. But the different ways apparently in which the genitalia are modified within the same order, would suggest that such a conclusion was not tenable. The genitalia have been used by some writers almost to the exclusion of all other structures for the separation of species and, while they undoubtedly possess characters of the greatest value, the other structures should receive equal consideration. The genitalia consist of a number of curved surfaces with hooks and projections that

vary in form with each angle from which they are observed and the greatest care must be used in employing such characters and in making comparisons to see that they are always examined from exactly the same angle. Such characters must be used with the greatest discretion. That the genitalia are of value in certain groups for the differentiation of species is unquestioned. But like most other structural characters, they are undeveloped or unmodified in many insects and in such cases are of no taxanomic value.

This diversity in belief leads to the necessity for establishing the primitive form of the genitalia, particularly if the homology of the various appendages and parts are to be determined throughout the entire insect-series. This is especially true if the genitalia are to be made the basis for phylogenetic studies. That the male and female without any indication of genitalia can not be adopted as the starting point is self-evident, since the embryos of all generalized species known bear appendages on these segments. The presence of a pair of appendages for each segment is a primary characteristic of the phylum. That the absence of appendages is not a primitive condition, but an acquired one, is suggested by the interruption and great diversity in the distribution of this condition throughout the orders and families of insects. That the individual with completely formed genitalia, as the ovipositor of the locust, cannot be adopted as the primitive condition, is just as evident, because such genitalia also represent a very different condition. That the presence of complex genitalia is not a primitive condition is also suggested by the interruption and great diversity in the distribution of this condition. Since none of the conditions named can be accepted as the starting point, we must assume that the primitive condition was one where abdominal segments eight, nine, and ten each bore a pair of short appendages. These appendages were not only short but probably unsegmented or at least soon acquired this condition. Since the external openings of the reproductive organs, the vulva and the meatus, are associated with these appendages, it is not difficult to understand how the appendages became modified through change in form and change in position into more efficient structures for ovoposition and copulation. Once such a line of modification was started, it is easy to comprehend how the appendages became modified and developed in many different directions. That the genitalia represent a single continuous line of descent is very doubtful, since they occur in such a great variety of forms not only in widely separated but closely related groups. Our knowledge is too limited at present to confirm or to deny such a conception. That the absence of genitalia is not

an indication of generalization, particularly if the primitive insects had appendages on segments eight, nine, and ten, but a specialization by reduction, while the presence of organs for ovoposition and clasping, as in many Orthoptera and Hymenoptera, is not an indication of generalization but an example of specialization by addition, is evident.

The anal opening is located beneath the eleventh tergum or in the coria, probably representing the eleventh segment, attachd to the tenth segment. The lumen of the rectum is lined with cuticle and is consequently preserved like the vagina and ejaculatory duct after treatment with caustic potash. This cuticle is consequently of great value in identifying the position of the anus. In a few insects where there has been a great depression of the caudal end of the abdomen and an obliteration of the segmasutures, the anus has migrated cephalad from its primitive position through the caudal abdominal segments.

The appendages of the eleventh abdominal segment, the cerci, are frequently long, slender, antennae-like organs in generalized insects, but in specialized insects they are greatly reduced in size, consist of only a few segments, often one or two, and are frequently wanting. The cerci when present, evidently have a tactile function in all insects. When the genitalia are retracted into a genatasinus, the cerci are frequently closely associated with the genitalia and the cerci appear to constitute a part of the genitalia and have been included with the genitalia by some writers. That the cerci are morphologically direct derivates from the limb-rudiments of the eleventh segment of the embryo is not questioned.

The close association of the anal opening and the eleventh segment in generalized insects, would suggest that the folds of coria surrounding the anus in specialized insects, where only ten segments can be identified as a rule, must represent the eleventh segment and should be so considered. Some of the species which have the eleventh segment represented by coria, also bear cerci, the appendages of the eleventh segment. These appendages of necessity are associated with the tergum of the tenth segment, but in generalized insects the articulations of the cerci are always closely associated with the tenth tergum, so closely, that they have been described as the appendages of this segment. That their position in specialized insects is an acquired one and not a primary condition is evident.

The segments of the abdomen can be very conveniently differentiated in the same way as the thoracic segments by the use of prefixes, as follows:—una for the first segment, dua from duae for

the second segment, tre from tres for the third segment, qua from quattuor for the fourth segment, qui from quinque for the fifth segment, sexa from sex for the sixth segment, septa from septem for the seventh segment, octa from octo for the eighth segment, nova from novem for the ninth segment, deca from decem for the tenth segment, and unda from undecim for the eleventh segment, the final vowel being elided when unnecessary. These prefixes are applicable for use with the segmacoria, the terga, the sterna, all other parts.

Segments.—There are typically eleven segments in the abdomen, as is shown by the number of segments in the embryo, the number of limb-rudiments, and the number of neuromeres. This number can be identified in some generalized adult insects, but the most frequent number in adult insects is ten. The eleventh segment, if present in adult insects, is usually membranous. The segments consist of transverse bands or plates, sometimes incorrectly called joints. They are numbered, beginning at the cephalic end, from one to eleven.

Segmacoria.—There is a transverse area of corea, the segmacoria, located typically cephalad of each segment. These coriae are usually broad and distinct, and can be differentiated by the use of the prefixes already indicated. The segmacoriae are homologous with the procoria, mesocoria, and metacoria of the thorax. The abdominal segmacoriae are only rarely modified into sutures, but if so modified, they can be designated and differentiated by the use of prefixes, thus, unasuture, duasuture, tresuture, etc. These sutures are known collectively as the segmasutures.

Latacoria.—The coria located typically on each side of each segment of the abdomen between a tergum and a sternum is a latacoria. Whether this region is homologous with the notacoria of the thorax as is frequently considered, is doubtful. The latacoria is more likely the equivalent of the entire area of a thoracic segment between the notum and the sternum, the pleuron being a specialization and expansion due to the development of wings and the necessity for more space for storing the muscles that operate them. When a latacoria is reduced to a suture it is known as a latasuture.

Latalla.—The latacoria of certain segments in a few generalized groups contains some small chitinized areas or sclerites, the latallae. The number of latallae on each side varies from one to three for each segment and the cephalic one usually bears a spiracle.

Tergum.—The dorsal plate of each segment is known as a tergum. Those of the caudal segments are frequently greatly reduced in size. In most insects each tergum consists of three areas, a cephalic infolded area, the pretergite, a mesal exposed area, the

medatergite, and a caudal infolded area, the postergite. The pretergite and postergite, while normally infolded, may be fully exposed, but when infolded the segmacoria is concealed at the bottom of the infolding. The various terga and tergites can be differentiated by the prefixes applied to the segments.

Sternum.—The ventral plate of each segment is known as a sternum. The caudal sterna like the caudal terga are usually greatly reduced in size. Each sternum may be modified into three regions, a presternite, a medasternite, and a poststernite. Such subdivisions are not of such general occurrence as with the terga. The various sterna and sternites can be differentiated by the prefixes applied to the segments. The sternites are sometimes divided into a mesal portion, a mesasternite or into a lateral portion on each side, a latasternite. The sterna sometimes extend as plates onto the dorsal aspect when they are known as dorsasterna.

Spiracles.—The external openings of the respiratory system, the spiracles, also known as stigmata, are located on segments one to eight and can be differentiated by the use of the prefixes applied to the segments. The number of spiracles is often reduced at the caudal end of the abdomen by the infolding of the segments and at the cephalic end by the encroachment of the metathorax upon the first or the first and second segments.

Plica.—The lamellate infolded thickenings on the cephalic and caudal margins of the terga and sterna of the abdomen are similar to the phragmata of the thorax and are known as plicae. The plicae of the terga are known as dorplicae and those of the sterna as venplicae. Those of the cephalic margin of the segment as predorplicae and prevenplicae and those of the caudal margin as postdorplicae and postvenplicae. Further differentiation can be secured by attaching the abbreviation of the name of the segment, una, dua, etc. Thus, unapredorplica is the plica on the cephalic margin of the tergum of the first abdominal segment.

Genatasinus.—The caudal end of the abdomen in either male or female may be infolded or telescoped so that only three or four segments are exposed, usually there are five or six or more. The cavity formed by the infolding, which serves to hold the proximal portions or all of the genitalia and cerci or the end of the abdomen when the genitalia are wanting, is known as the genatasinus. It is also known as the genital pouch.

Cercus.—Each of the appendages of the eleventh segment is a cercus, also known as a cercopod or caudal seta or anal cercus. In generalized insects the cerci are usually long and many-segmented, antenna-like, and are undoubtedly used as organs of special sense.

They are sometimes greatly reduced in size, consisting of a single segment, this segment may be greatly enlarged and sometimes modified into a forcep. The cerci may also be concealed with the genitalia in the genatasinus.

Alacercus.—Insects sometimes have three long slender antenna-like structures. The mesal appendage in such cases is not a true appendage but an extension of a tergum that has been secondarily segmented, which probably if not always is a part of the tenth tergum. This appendage is known as the alacercus to distinguish it from the true cerci. It is also known as the caudal filament, the median caudal filament, or telofilium.

Genitalia.—The appendages associated with the external openings of the reproductive organs in the male and female, the genital claspers and the ovipositor are known collectively as the genitalia. This includes not only the appendages of the eighth, ninth, and tenth abdominal segments but such projections and other structures derived from the terga and sterna of these segments as may constitute an integral part of the accessory structures having to do with reproduction.

Gonapophyses.—The structures derived solely from the appendages of segments eight, nine, and ten, are known as the gonapophyses. They constitute a primary part of the claspers and ovipositor.

Ovipositor.—The structure in the female formed from the appendages of the eighth, ninth, and tenth segments together with any accessory parts derived from the terga and sterna and used in inserting the eggs in animals or plants is known as an ovipositor.

Valvae.—Each of the appendages of the eighth, ninth, and tenth segments which in the female forms one of the leaves of the ovipositor is known as a valva. The close apposition of the valvae forms a tube through which the eggs are passed during ovoposition. They are also known as valvulae.

Octavalvae.—The appendages of the eighth abdominal segment which form one of the pairs of projections of the ovipositor are the octovalvae. They are also known as the ventral or anterior valvulae or anterior ovipositors. The octavalvae constitute important parts of the ovipositor. In the adult they are usually associated with the eighth segment.

Novavalvae.—The appendages of the ninth abdominal segment in the female are the novavalvae. They are also known as the dorsal or lateral valvulae. The novavalvae are usually smaller than the other valvae and, when one pair of valvae is wanting or transformed into a different structure, it is usually the novavalvae that

are so modified. They are known as the forked organ in certain Orthoptera, Acrididae.

Decavalvae.—The appendages of the tenth abdominal segment in the female are the decavalvae. They are also known as the inner or posterior valvulae or the dorsal or posterior pair of ovipositors. They are usually associated with the ninth segment in the adult. The decavalvae are usually subequal in size to the octavalvae.

Octavalvifer.—The plate borne on the proximal part of the lateral surface of each octavalva in many orthopterous insects is an octavalvifer. It is also known as a basivalvula.

Decavalvifer.—The plate borne on the proximal part of the lateral surface of each decavalva in many orthopterous insects is a decavalvifer. It is not of as general occurrence as the octavalvifer and is also known as the valvifer.

Telson.—The caudal tergum in orthopterous insects is usually a flat plate divided into two parts by a transverse furrow. This plate is known as the telson and the two parts are considered by some as the terga of the eleventh and twelfth segments. The transverse furrow is usually distinct in adult insects but may be wanting in nymphs.

Supranalis.—The caudal half of the telson in orthopterous insects is known as the supranalis. It is also known as the supraanal plate, twelfth segment.

Subgenitalis.—The eighth sternum in certain insects forms a large movable plate and is known as the subgenitalis. It is also known as the subgenital plate.

Bursa.—There is in lepidopterous insects a special copulatory pouch present in which the seminal fluid is said to be received. This pouch is known as the bursa copulatrix or simply as the bursa. It should not be confused with the genatasinus which is an infolding or telescoping of the caudal end of the abdomen and a structure of a very different nature from the true bursa.

Latatergum.—Each lateral portion of most or all of the abdominal terga may be folded onto the lateral or ventral aspect as a distinct narrow longitudinal area. Each of these areas is known as a latatergum.

Margatergum.—There is frequently a sharp ridge separating each latatergum from the mesal portion of a tergum, a margatergum.

Paraproct.—The plate on each side of the undatergum or telson in many orthopterous insects is a paraproct. Each is also known as a podical plate. They are considered as a part of the undatergum.

Septasternum.—In generalized insects the septasternum consists of a single piece and bears a pair of stylets, the appendages of the ninth segment. The septasternum in the males of certain insects is divided by furrows into three parts, a mesal portion and two caudo-lateral portions. The mesal portion has been called the sternite and each caudo-lateral portion a coxite. When the coxites are fused but remain separate from the sternite, they have been named the coxale and when all the furrows are wanting and the coxites and sternites are supposed to form a single undivided piece as in generalized insects, the septasternum has been named the coxosternum.

Vulva.—The external opening of the vagina, which is usually of some size and generally surrounded by folds of coria, is the vulva. It varies somewhat in position, but is frequently situated between the septisternum and octasternum or in the octasternum.

Pseudopositor.—The name of ovipositor is applied by most writers to all structures used by the female in placing her eggs regardless of the composition of the parts. The name of ovipositor is here restricted to the structure composed of all or a part of the appendages of the eighth, ninth, and tenth segments. Many females have the abdomen caudad of the fourth or fifth segment reduced to a slender tube, which is retracted within a genatasinus. This tube can often be extruded for a distance as great or greater than the length of the abdomen or the abdomen and thorax together and is used in placing the eggs in cracks, crevices, within the pulp of fruit, or in soft substances of various kinds. Such a structure usually lacks all appendages with the possible exception of the cerci and is known as a pseudopositor.

Preabdomen.—When the caudal segments of the abdomen are retracted within a genatasinus, the exposed segments are known as the preabdomen.

Postabdomen.—The segments of the abdomen that are retracted in a genatasinus are known collectively as the postabdomen.

Spermora.—The duct of the spermatheca may empty into the dorsal surface of the vagina or it may open externally and independently. The mouth of the duct is known as the spermora.

Spermoraria.—The spermora is sometimes located in a special cuticular area. This is the spermoraria.

Collatoria.—The duct of the collaterial gland, like that of the spermatheca, may open into the vagina, usually the ventral surface, or externally and independently. The mouth of this duct is the collatora.

Cercaria.—The small sclerite articulated to the proximal end of

each cercus is a cercaria. It is also known as the basopodite of the cercus or cercal basopodite.

Saccula.—There is a pair of blind reddish sacks present in the genatasinus of certain grasshoppers, one on each side of the vulva, which evidently have something to do with copulation, since each is operated by a large muscle attached to the inner end, by means of which they can be extruded or retracted. The function of these sacks is not known. They are the sacculae.

Basarcus.—The curved strongly chitinized area cephalad of the octavalvae in the cockroach is the basarcus. It has a distinctly curved periphery and is also known as the basal arch.

Octapophysis.—The stout enlargement at the proximal end of each octavalva and against which it articulates is an octapophysis or inferior apophysis.

Decapophysis.—The thickening at the proximal end of each decavalva and against which it articulates or of which it is a continuation is a decapophysis or superior apophysis.

Proxavalvaria.—The chitinized area, sometimes indefinite, connecting the proximal ends of the decavalvae is the proxavalvaria. It is also known as the inferior intervalvula.

Distavalvaria.—The chitinized area, frequently more distinct than the proxavalvaria, situated in the bottom of the furrow between the novavalvae is the distavalvaria. It is also known as the superior intervalvula.

Meatus.—The external opening of the ejaculatory duct is known as the meatus. It is situated in the novasternum or between the novasternum and decasternum.

Aedeagus.—The external opening of the male genital duct is usually borne upon a more or less prominent projection, the aedeagus. This projection is also known as the penis. When the aedeagus is strongly chitinized and prolonged beyond the meatus, the prolongation is known as the virga.

Paramere.—The bifurcate or pointed projection attached to the floor of the genatasinus in the males of orthopterous insects are known as the parameres. They are frequently arranged in pairs and placed asymmetrically. The caudal paramere is the right paramere or dexaparamere and the cephalic paramere is the left paramere or sinaparamere. The parameres probably function as claspers.

Peronea.—The strongly chitinized and deeply transversely infolded area cephalad of the sinaparamere is the perona. This structure is also known as a clasper. While it may have this function, it is undoubtedly an important place for the attachment of

muscles. The cephalic perona is the preperonea and the caudal peronea is the postperonea.

Brachia.—The finger-like structures surrounding the aedeagus in orthopterous insects, frequently situated near the dexaparamere when that structure is present, is known as the brachia. It is generally a paired structure and is also known as the clasper, as a paramere, or as the aedeagus.

Clasper.—The lobe or paddle-like plate in male lepidopterous insects attached on each side of the caudal end of the abdomen is known as a clasper. Each is generally of considerable size and the fact that it is a paired structure will distinguish it. This is apparently the structure named the valva by some writers.

Harpe.—The structure attached to the ventral margin of the mesal surface of each clasper is known as a harpe. The distal free end may be simple, but is often bifurcate, fork-like.

Tenth Segment.—The strongly chitinized mesal structure attached above and projecting between the claspers in lepidopterous insects is known technically as the tenth segment. The distal end of this structure is known as the uncus, which may be a single long undivided structure or it may be furcate or divided. The tenth segment bears the anus.

Endoparamere.—The lateral end of the peronea, which is usually placed upon one side, is produced internally as a stout parademe. This parademe is known as the endoparamere.

Pygidium.—The last tergum exposed caudad of the elytra in coleopterous insects has been called the pygidium. This name is applied to the last tergum regardless of its homology or number. In the Coccidae the four caudal segments typically form a chitinized inflexible area in the Diaspidinae. This area is also known as the pygidium.

Propygidium.—In those insects where a pygidium can be identified, the segment in front of the pygidium is known as the propygidium.

Hypopygium.—The last sternum exposed caudad of the elytra is known as the hypopygium. It is also known as the propygium and this latter is also sometimes known as the genitalia.

Campanulate.—The terga and sterna of the abdomen in some insects are convex on the cephalic margin and concave on the caudal margin. The segments, because of such a form, are crescentic and as a result each successive segment toward the caudal end is narrower. The convex cephalic end of one segment fits into the concave caudal margin of the preceding segment. The concavity in the caudal end of the next to the last segment is filled by the plug-like

caudal segment, which has its caudal margin convex. Where the abdomen has such an arrangement of its segments it is said to be campanulate.

Furcula.—There is in the males of certain species of Orthoptera, Acrididae, a forked structure, the furcula, which projects from the dorso-mesal portion of the decacoria over the decatergum and the proximal portion of the undatergum or appears to be a continuation of the decatergum. The fork is formed by an oblique projection situated on each side of the meson. The sides of the fork are sometimes greatly reduced in size and represented by a minute tubercle. The furcula is of limited occurrence and is not always equally prominent in all the individuals of the same species.

Egg-guide.—The mesal part of the distal end of the octasternum is prolonged in the Acrididae into a slender finger-like projection. This projection extends between the octavalvae and is concealed from view from the ventral aspect unless the octavalvae are spread apart or the octasternum is pulled ventrad. The free end of the egg-guide can be seen, when it is in place, projecting dorsad of the octavalvae. The function of the egg-guide is evidently to hold the eggs against the spermora as they are extruded.

Blatta Orientalis.—The sexes can be distinguished by the presence of rudimentary wings, a single pair of caudal appendages, and a divided caudal sternum in the female and by the presence of functional wings, two pairs of caudal appendages, an undivided caudal sternum in the male.

Female.—The segmacoriae are long and flexible. The unitergum is short, extends to the lateral margin, and lacks lataterga. Its cephalic half is covered by the metanotum. The second to sixth terga are similar in form, shorter on the meson than at each lateral margin, the caudo-lateral angles pointed. The seventh tergum is narrower than the sixth, has large sharp caudo-lateral angles. The caudal margin is bluntly rounded at middle and emarginate between the mesal projection and the lateral angles. The octatergum and novatergum are usually concealed by the septatergum. The large caudal triangular projection, angularly emarginate at the caudal end is the decatergum. The cephalic portion is broadest. Each cercus is attached beneath the collar-like lateral portion of the decatergum and consists of about thirteen flexible flattened segments.

Draw the dorsal aspect of the abdomen and name all the parts.

The unasternum consists of the three primary fields found in the thorax, a median transverse oval area and two whitish membranous areas, extending on each side to the unatergum. The dua-

sternum also consists of three fields, the median field is octagonal, bounded by a line-like suture. Each lateral field is large and transverse and is diveded by a transverse carina into two parts. The area cephalad of the carina is the surface upon which a metacoxa rests. The third to sixth sterna are similar. The septasternum is narrower and longer than the sexasternum. It consists of three areas, a cephalic transverse area and a triangular valvular area or lobe continuous with each side of the cephalic mesal area. The mesal margins of the valvular areas are connected by loose folds of coria. The mesal furrow separating the valves is continued laterad between each valve and the cephalic part of the septasternum. The second to seventh segments are provided with narrow lataterga. The latacoriae are broad, but concealed by the close apposition of the sterna and latatergae. Separate these parts in a prepared specimen and identify the small sclerite in the dualatacoria. This is a latalla. There is only one in each latacoria. The unalatacoria is attached to the unatergum. The octalatellae are fused with the octatergum. The spiracles are located in the latallae, the first pair dorsal, the others lateral, eight pairs in all.

Draw the ventral aspect of the abdomen and name all the parts.

Genitalia.—Study a treated specimen. Identify again the septatergum. Expose the much shorter octatergum and the octalatellae and octaspiracles. The novatergum is not so long as the octatergum. The decatergum has been identified. Note again each cephalo-lateral portion which curves around the proximal segment of a cercus. Identify the plate on each side ventrad of the decatergum and caudad of a cercus, the undatergum, each is also known as a paraproct. They are wedge-shaped areas with dorsal and ventral surfaces. The mesal margins are connected by coria. The lateral angles of the decatergum and undatergum are closely associated. The undacoria is very long. The cerci are attached to this coria. Each is provided with a slender semicircular cercaria. The anus is located in the coria between the two plates of the undatergum. Identify again the septasternum. Note that the proximal transverse part of the septasternum is opposite the septatergum. The two caudal valvular lobes are connected on the meson by coria. There is a thin plate extends from the caudal end of the mesal margin of each lobe into the coria. This coria extends onto the dorsal aspect of the septasternum and surrounds the large foot-shaped plate situated near each caudo-lateral angle of the transverse part of the septasternum. There is another smaller plate located near the foot-shaped plate. All these plates and the connecting coria belong to the dorsal part of the septasternum and form the ventral surface of

the genatasinus in which the following sterna and the appendages are retracted. This gives great flexibility and allows for the holding of the ootheca as it is formed. The proximal part of the ovipositor is retracted and the cuticular area covering the octavalvae is considered as a portion of the dorsal part of the septasternum. The peripheral margin of this chitinized area is arched, forming together with the other chitinized parts, the basarcus. There is a large area of concentrically folded coria on the meson of the basarcus. This coria marks the position of the vulva. The oviduct is usually destroyed in preparation. Turn the basarcus aside and expose the large convergent swollen areas, the octapophyses, against which the finger-like octavalvae articulate. The small subglobular area situated between the octapophyses, the spermoraria, has two points at the caudal end between which there is a small opening, the spermora. The narrow transverse area on each side articulating against the octatergum and novatergum is a lateral part of the octasternum and novasternum. The lateral portions of these two sterna are distinctly separated by coria while the mesal portions are separated by a furrow. The proximal portion of an octavalva is fused with an octasternum. The large lateral finger-like arms under the octavalvae are the decavalvae. They are attached to each lateral part of the novasternum, which is enlarged adjacent to the union. The proximal parts of the decavalvae are adjacent. The much smaller pair of fine finger-like appendages located between and attached to the decavalvae are the novavalvae. The chitinized area uniting the proximal end of the decavalvae is the proxavalvaria and that in the notch between the novavalvae is the distavalvaria. The area caudad of the decavalvae and novavalvae belongs to the decasternum and undasternum.

Draw the dorsal surface of the genatasinus and name all the parts.

Male.—The abdomen of the male is more slender than that of the female. The septatergum is subequal in length and width to the others. Its caudal margin is hollowed out on each lateral third. The octatergum and novatergum are much shorter than the others, but both are distinctly exposed. The decatergum is broad and long. The caudal end is slightly emarginate. Each cephalo-lateral portion is produced collar-like. This collar surrounds the cercus as in the female.

Draw the dorsal aspect of the abdomen and name all the parts.

The median field of the unasternum is large and distinct. The lateral fields are small and reduced by the encroachment of the metacoxacoriae. The median and lateral fields of the duasternum are distinct. The third to seventh sterna are similar in form. The

octasternum is much shorter than the one cephalad of it. The novasternum is longer than the octasternum and its caudal margin is convex. The elongate cylindrical one-segmented appendage attached on each side of the meson to the caudal margin of the novasternum is a stylus, one of the appendages of the ninth segment.

Draw the ventral aspect of the abdomen and name all the parts.

Genitalia.—Study a treated specimen. The genitalia have been described as if all the parts were extruded and the floor of the genatasinus was flat. Success in the identification of the parts depends upon all the parts being fully extruded. Identify again the novasternum which bears the stylets. Also the caudal exposed tergum, the decatergum. The short transverse plate on each side of the meson is a paraproct, a lateral portion of the undatergum. The median portion of this tergum, the telson, is composed of coria and continuous with the undasternum. The floor of the genatasinus, therefore, belongs wholly to the decasternum. Since the cerci are the appendages of the undasegment and the stylets those of the novasegment and since the appendages of the octasegment and decasegment atrophy during embryological development, the genitalia are, therefore, modifications of the decasternum and the cuticular parts of the aedeagus. The sinistral sclerite caudad of the novasternum is the left part of the decasternum, the sinadecasternite. The mesal portion of this sclerite is smaller and curved and pointed and the lateral portion is broadly rounded. The minute dextral sclerite at the mesal end of the sinistral sclerite is the other portion of the decasternum, the dexadecasternite. The two long arms at the lateral end of the dextral portion of the decasternum is the dexaparamere. It consists of two parts. A long slender curved barbed lateral projection and a short blunt lateral projection. The distal end is bluntly recurved and the lateral margin is provided with a long roughened bar-like area. The dexaparamere is produced internally as a short parademe. The three projections located between the dexaparamere and the sinadecasternite are the brachiae. The three projections or lobes are its distal portions. The dextral lobe of the brachia is broad and blunt with a cuticular plate on the mesal side. Of the other two projections, the longer one is provided with a long pointed recurved end. This lobe of the brachia is produced internally as a parademe for the attachment of muscles. The aedeagus is located in the coria on the caudal side of the proximal end of the brachia. It is composed of coria in great part and is rarely extruded in specimens for study. The strongly chitinized invaginated plates located in the coria on the sinistral side cephalad of the large sinadecasternite is the peronea. It is deeply trans-

versely infolded at middle. The cephalic plate is the preperonea and the caudal plate is the postperonea. The peroneae are supposed to function as claspers and have been so named. They are important places for the attachment of muscles. The lateral end of the peronea is produced internally as a large parademe, the endoparamere. The pair of arms fused to the caudal margin of the postperonea is the sinaparamere. The arms are very much twisted and curved, one terminates in two parallel projections and the other in a single long slender projection.

Draw the dexaparamere, the brachiae, and associated structures and name all the parts.

Draw the sinaparamere and the peronea and name all the parts.

Draw the floor of the genatasinus showing all its structures and name all the parts.

Melanoplus Differentialis.—The sexes are easily distinguished. The female has the cephalic end of the abdomen larger than the caudal, which is provided with hooked projections, while the male has the cephalic end smaller than the caudal end, which is hood-shaped.

Female.—The unatergum is separated from the unasternum by the metacoxae. The unasuture is distinct. Each lateral portion of a unatergum bears an opaque oval membrane, a tympanum, an external part of an auditory organ. The second to seventh terga are similar. The segmacoriae are short, joining the telescoped posttergite of one segment to the pretergite of the next. The terga cover the dorsal and lateral aspects. The latacoriae are distinct. Latallae are wanting. The octatergum differs from those cephalad of it only in being shorter and in having its lateral margins longer. The unaspiracles are located near the middle of the cephalic margin of the tympana. The spiracles of the second to eighth segments are situated in the cephalic part of the lateral portion of their respective terga. The novatergum and decatergum are very short, together not as long as the octatergum. The novacoria is distinct, the decacoria is obsolete on each lateral portion where the two terga are fused. The mesal portion of the decatergum is shorter than the lateral. The triangular mesal area attached to the decatergum is the undatergum or telson. It is divided into two portions by a transverse furrow, the caudal portion is the supranalis. The triangular plate on each side of the undatergum is a paraproct, an integral part of the undatergum. The small bluntly pointed structure resting upon each paraproct and projecting from the undacoria is a cercus. The cercaria is small, but distinct. The flask-shaped area dove-tailed into the metasternum is the unasternum. The second to seventh sterna are similar. The segmacoriae are long.

The octacoria is continuous on the dorsal and ventral aspects. The octasternum is longer than the septasternum. Its distal margin consists of three projections, a mesal projection, the egg-guide, and a prominent angular projection on each side. The four stout hooked projections between the undatergum and the octasternum are the ovipositor. The ventral pair of hooks is the octavalvae and the dorsal pair is the decavalvae.

Draw the lateral aspect of the entire abdomen and name all the parts.

Draw the dorsal aspect of the abdomen caudad of the octatergum and name all the parts.

Genitalia.—The octasternum forms a subgenital plate. The egg-guide projects finger-like between the octavalvae. Each lateral angular projection of the octasternum rests upon a triangular plate, an octavalvifer, which is situated upon the lateral surface of an octavalva. Turn the caudal end of the octasternum back and observe the restricted genatasinus. The dorsal surface of the octasternum is coria. The vulva is a V-shaped opening located on the meson of the cephalic part of the dorsal surface of the octasternum. There is a shallow blind pocket in the coria on each side of the vulva, a saccula. These are true eversible glands. They are reddish in color in recently killed specimens and each is operated by a large muscle. Their function is unknown. The divergent brownish bars at the proximal ends of the octavalvae are the octapophyses. The plate distad of each octapophysis is the ventral part of an octavalvifer. The small opening on the meson between the proximal parts of the octavalvae is the spermora. It is situated in a boat-shaped area of folds and thickenings. The brownish plate on each side between the proximal ends of the octavalvae and decavalvae represents a part of the fused novasternum and decasternum. The deep transverse infolding through the middle of each area marks the position of a decasuture. The long parademe invaginated at each lateral end of the decasuture of each plate is a decaplica, to which the muscles operating the ovipositor are attached. The novasternum and decasternum are located opposite the short novatergum and decatergum. The small irregular brownish sclerite between the proximal ends of the decavalvae is the proxavalvaria. The trough-shaped structure situated distad of the proxavalvaria is the novavalvae or, as it is commonly called, the forked organ, which is used in placing the eggs. The brownish chitinized area between the decavalvae and distad of the novavalvae is the distavalvaria. The coria between the decavalvae and the paraprocts represents the undasternum.

Draw the ventral aspect, showing the octavalvae and vulva, and name all the parts.

Draw the caudal aspect with the valvae vertical and name all the parts.

Male.—The abdomen of the male does not differ from that of the female except caudad of the eighth segment. The octatergum and octasternum with their latacoriae are the last to form a complete ring. The eighth segment can be identified from the presence of the octaspiracles. The novatergum is about as long as the octatergum, but the decatergum is much shorter. The decacoria is obsolete on each lateral aspect and the two segments are fused for a short distance. The mesal part of the decatergum is membranous. The caudo-mesal angles adjacent to this coria are usually prolonged, varying in size in different individuals. These projections represent the furcula, which is a forked organ in some species of this genus. The shield-shaped area at the caudal end of the decatergum is the undatergum, also known as the telson. The boat-shaped piece on each side of the telson and projecting free from the undacoria is a cercus. The cerci of the male vary in form with the species. Compare them with the cerci of the female. The triangular plate upon which each cercus rests is a paraproct, a part of the undatergum. The anus opens beneath the telson. The novacoria is continuous cephalad in front of the novatergum and novasternum. The large hood-shaped area caudad of the novacoria is the novasternum. There is a transverse indentation on each side caudad of the middle. The indentations are continued across the middle, forming a depression that has been interpreted as the undasuture. This indentation is one characteristic of adults only and is not accepted as a primary division of the sterna.

Draw the lateral aspect caudad of the octacoria and name all the parts.

Draw the dorsal aspect caudad of the octacoria and name all the parts.

Genitalia.—Identify again the decatergum and undatergum, also the novasternum. The decasternum is completely retracted and concealed, forming a genatasinus. Study a specimen in which the floor of the genatasinus has been spread out flat, exposing the novasternum and the projections upon its surface. The caudal part of the decasternum, probably the decacoria, consists of a broad area of folded corea. The greater part of the brownish mesal structures belong to the brachia. The dexaparamere is obsolete. The two swollen areas, only slightly chitinized, situated upon the caudal side of the proximal end of the brachiae represent the dexadecasternite and the sinadecasternite. The brachiae consist of two adjacent

projections. The caudal and the lateral surfaces of each projection of the brachiae are covered with a thick fold of coria. The surface of this coria is dotted with minute brownish spinulae. The mesal surface of each projection of the brachiae consists of an elongate brownish grooved plate. When the large lateral projections of the brachiae are pushed apart, there is exposed a pair of adjacent sword-shaped projections. The brachiae are joined to two large paired parademes. One pair is horizontal and located just beneath the cuticle of the surface. From each of these parademes a large arm extends caudad. The other parademe extends dorsad, each is prolonged into a thin convex-concave flaring plate. These parademes serve for the attachment of the muscles that operate the brachiae. The ejaculatory duct passes dorsad on the cephalic side along the mesal surface of the central projection uniting the parademes. The meatus is located on the cephalic side of the proximal ends of the mesal sword-shaped portions of the brachiae. The thickened infolded plate located some distance caudad of the brachiae is the peronea. The furrow dividing it into preperonea and postperonea is not prominent. The sinaparamere is obsolete. The peronea is the pseudosternite of some authors.

Draw the brachiae with its parts separated to show the four lobes and the parademes.

Draw the floor of the genatasinus with all its projections and name all the parts.

Harpalus Caliginosus.—The abdomen is depressed. The dorsal aspect is covered by the elytra and wings, which should be removed. The two sexes can be distinguished by secondary sexual characters. The male has the four proximal protarsal segments wider than long while these segments in the female, exclusive of the setae, are longer than wide. The hypopygium in the male bears a single seta on each side while there are two in the female.

Female.—The terga are soft and flexible. The unatergum is short and transverse. The unacoria is distinct. The unaspiracle is very large, more than twice as long as broad, located adjacent to the black metanotum. The second to sixth terga are similar. Their segmacoriae are distinct and their latacoriae are broad and each contains a prominent oval spiracle. The septatergum is longer than those cephalad of it, more strongly chitinized, darker in color, and setiferous. The septalatacoriae bear the small rounded septaspiracles. The octatergum is ordinarily retracted into the septatergum with only the caudal portion exposed. Extrude the octatergum so as to expose the octaspiracles, which are normally concealed. The third to seventh segments are provided with distinct

strongly chitinized dorsasterna. The tredorsasternum projects into the dualatacoria.

Draw the dorsal aspect of the abdomen and name all the parts.

The unasternum is obsolete. The duasternum consists of three parts, a triangular lateral part separated on each side from a minute mesal part by the metacoxae. The mesal part of the polished cephalic end of the mesal projection is concealed unless the metathorax and the tresternum are separated. The tresternum is complete. There is a deep emargination on each side of the meson into which the metacoxae fit. The mesal projection is the abdominal coxal process. The fourth to sixth sterna are continuous and similar. The septasternum is semicircular and is ordinarily the last sternum exposed. The caudal end of the octasternum is sometimes exposed. The fourth to seventh sterna bear on each side of the meson near the caudal margin, a single long seta. These are the ambulatory setae. There is normally an additional long seta near the middle of each half of the caudal margin. The second to seventh sterna are provided with distinct latasterna in which the elytra are fastened.

Draw the dorsal aspect of the abdomen and name all the parts.

Genitalia.—Identify again the septatergum. The other terga and sterna are completely retracted in a genatasinus. Extrude the concealed sterna, if not exposed by the application of pressure near the middle of the abdomen then pull them out with forceps. The octatergum is shield-shaped. The caudal end is pointed and projects over the novatergum. This tergum is soft and flexible, lighter colored, and deeply retracted within the eighth segment. The decatergum is similar to the octatergum in general appearance but smaller. The octasternum is shield-shaped, divided into two parts on the meson by coria. The novasternum is similar to the novatergum in structure. The pair of appendages attached to the caudal part of the novatergum is considered as the octavalvae. Each consists of a triangular octapophysis and a two-segmented arm. The area located on the meson between the free parts of the octavalvae is the decasternum. The vulva is located in the decacoria. The mesal black band of the decasternum extends into the vagina. The abdomen when extruded is used for placing the eggs and constitutes a pseudopositor. The anus is located between the decatergum and decasternum.

Draw the dorsal aspect caudad of the octacoria and name all the parts.
Draw the ventral aspect caudad of the octacoria and name all the parts.

Male.—The abdomen of the male differs from that of the female only in the number of ambulatory setae.

Genitalia.—The segments and appendages caudad of the

seventh segment are retracted in a genatasinus. The octatergum is a small transverse shield-shaped plate similar in form to the septatergum, but smaller. The novatergum consists entirely of coria, which is flexible and retracted under the projecting octatergum. The decatergum is a short transverse area projecting only slightly caudad of the octatergum. The caudal margin is more strongly chitinized. The anus is located beneath the octatergum. The octasternum is completely retracted under the septasternum. It is divided into three parts, a mesal portion consisting of coria and a lateral chitinized plate on each side. The distal margin of each of these plates is obliquely emarginate. The novasternum is asymmetrical. The dextral plate, occupying one-half or more of its surface, is strongly chitinized. The mesal portion is prolonged caudad as a distinct bluntly rounded lobe. The caudal margin of each side of this lobe is emarginate. The emargination of the mesal side is broader and more distinct than the lateral. The decasternum consists entirely of coria. The aedeagus is extruded through this coria. It is a long blackish, strongly curved, tubular structure, nearly one-half as long as the exposed portion of the abdomen. The proximal portion is swollen. The distal portion is oblique. The concave side is filled with coria on the distal one-third of its length. The distal part of this coria contains the meatus. The tip of the aedeagus is prolonged beyond the meatus into a pointed virga.

Draw the dorsal aspect of the abdomen caudad of the sexatergum and name all the parts.

Draw the ventral aspect of the abdomen caudad of the sexasternum and name all the parts.

Protoparce Sexta.—Study specimens that have been denuded of their scales. Handle specimens carefully, do not tear the coria, considerable time is required to prepare the specimens. The two sexes can be distinguished by the form of the antennae. The setae on one side of the segments of the flagellum of the male are much longer than those of the female. The antenna of the male appears to be distinctly pectinate.

Female.—The unasuture is distinct and the unatergum is long. There is a large tergonta extends obliquely from the lateral part of the dorsal portion of the unasuture to the postergite. The cephalic ends of the tergontae are attached to a large unapredorplica. The second to sixth terga are similar, becoming gradually narrower with a reduction in the size of the segments toward the caudal end. The postergite of the second to sixth is as a rule larger than the adjacent pretergite. They are both glabrous, the caudal margin of the medatergite is fringed with long slender black setae. The septatergum is

longer than the other terga and strongly narrowed toward the caudal end. The laterotergites are broad. The [illegible] are large and located near the [illegible] and the lateral margin of the tergite. The spiracles of the second to the seventh segments are located in line with the [illegible]. The [illegible] are smaller than the others. The [illegible] are [illegible].

Draw the lateral aspect of the abdomen and name all the parts.

The [illegible] is [illegible]. The [illegible] forms the lateral boundary of the [illegible] and [illegible] and is united to the [illegible] by a [illegible]. Each cephalo-lateral angle of the [illegible] is prolonged to form a long slender [illegible]. The second to [illegible] sterna are similar in length but successively narrower toward the caudal end of the abdomen. [illegible] and [illegible] are located on the second to the sixth sterna. The [illegible] is much longer than the others with the lateral margins converging caudad and with the caudal margin deeply emarginate. The third to the seventh sterna are connected by [illegible] to the third to the seventh terga.

Draw the ventral aspect of the abdomen and name all the parts.

Genitalia.—Identify again the [illegible] and the [illegible]. All the terga and sterna caudad of the [illegible] are [illegible] [illegible]. Obtain a specimen that has been fully [illegible]. The [illegible] is the [illegible] [illegible] area caudad of the [illegible]. It is joined to the [illegible] by a long [illegible]. The [illegible] is composed entirely of [illegible]. The [illegible] is strongly [illegible]. It is a [illegible] [illegible] area deeply [illegible] [illegible] on the [illegible]. The [illegible] portion is produced laterally as a [illegible] [illegible]. The lateral ends of the [illegible] and [illegible] are fused. Each is produced [illegible] as a long slender [illegible]. There is a large [illegible] caudad of the [illegible]. The caudal portion of the [illegible] forms one side of the opening, the vulva, through which the vagina opens. The caudal portion of the vagina is a strongly [illegible] [illegible] tube. The [illegible] is located near the cephalic end of the [illegible] part of the vagina. The [illegible] [illegible] a [illegible] [illegible] area adjacent to the vulva, [illegible] of [illegible]. The [illegible] caudal end [illegible] being [illegible] placed [illegible] to the [illegible]. It is [illegible] modified into a [illegible] and a [illegible]. The [illegible] end is [illegible] [illegible] and contains the anus. The [illegible] part of the [illegible] aspect is flat and [illegible]. The cephalic end of each of the [illegible] [illegible] of the [illegible] is produced into a long slender [illegible]. The [illegible] or [illegible] can not be identified. The [illegible] segments can be [illegible] and form a [illegible].

Draw the dorsal aspect caudad of the septatergum and name all the parts.

Draw the ventral aspect caudad of the septasternum and name all the parts.

Male.—The abdomen of the male is similar to that of the female in general appearance. The latacoriae are not as broad and the terga and sterna are closer together. The spiracles, which are located in the latacoriae, are sometimes concealed on the caudal segments by the folding together of the terga and sterna.

Genitalia.—Identify again the septatergum and the septasternum. This is easily accomplished by identifying the segment bearing the last pair of spiracles, the septaspiracles. The octaspiracles are always wanting in the adults of all lepidopterous insects so far as known. The octatergum is the last exposed tergum. It is narrowed toward the caudal margin, which is fringed with long black setae. The octacoria is long. The octalatacoriae are broad. The octasternum is only about one-half as long as the octatergum and it is a broad more or less flexible area. The novatergum and novasternum consists entirely of coria. The large paired chitinized plates or lobes attached to this coria are the claspers. The dorsal margin of each clasper is concave. The distal and ventral margins are convexly rounded, meeting the dorsal margin in a bluntly rounded distal end. The lateral surface of each clasper is flat and the proximal half is strongly chitinized. The distal portion in uncleaned specimens is densely covered with flattened scales. Spread the claspers apart and observe the mesal surface of each. The distal half is densely covered with long decumbent setae. The ventral part of the mesal surface of each clasper bears a strong forked structure, the harpe. One prong of the harpe is broad and rounded with the margin toothed while the other prong is pointed. There is a small swollen brownish plate near the cephalic end of the harpe. The cephalic ends of the claspers are produced internally as a large lobe-like parademe. The brownish tubular structure projecting through a collar-like sclerite between the claspers is the aedeagus. The meatus is located in the retractile coria located in the distal end of the aedeagus. The strongly chitinized mesal structure articulating against the dorsal margin of the cephalic ends of the claspers is the tenth segment. The arm articulating against a clasper is curved and bowed. The caudal portion of the tenth segment is known as the uncus. The end of the uncus is bifurcate in this species. The dorsal portion is beak-like and the ventral portion, which is much shorter, is a trough. The rectum extends

through the tubular coria extending between the two projections of the uncus with the anus at the distal end of the coria.

Draw the lateral aspect caudad of the septatergum and name all the parts.

Draw the dorsal aspect of the genitalia with the claspers spread apart and name all the parts.

Gryllus Pennsylvanicus.—The sexes are readily distinguished, a long exserted ovipositor in the female and the absence of any similar structure in the male, will separate them. The mesowings are modified into sound producing organs in the male and are of ordinary form in the female.

Female.—The unacoria is long on the dorsal aspect and the unatergum is a transverse plate with a mesal depression. The duacoria is long while pretergites and postergites are wanting. The second to the seventh terga are similar in size and their segmacoriae are long and distinct, more or less concealed. Several of these terga are provided with a mesal depression. The octatergum is similar to the septatergum but shorter. The novatergum is subequal in length to the octatergum on the dorsal aspect. It extends much further ventrad and is dilated into a rounded lobe on each side. The latacoriae are broad areas of whitish coria, narrower at the caudal end. Each contains eight spiracles, one opposite each lateral end of the first to eighth terga. Some of the cephalic and caudal spiracles are larger than the intermediate spiracles. The decatergum is a shield-shaped area on the dorsal aspect, longer than the novatergum. Each lateral third is reduced to a narrow curving band. The short shield-shaped area borne at the caudal end of the mesal part of the decatergum is the mesal part of the undatergum. It is also known as the telson. The anus is located ventrad of the telson. The long tapering unsegmented setiferous appendage attached caudad of each narrow band-like portion of a decatergum is a cercus. It is the appendage of the undasegment. The narrow crescentic bar located on the dorsum at the proximal end of each cercus is a cercaria. The convex plate located caudad of each cercus is a paraproct, a part of the undasegment.

Draw the dorsal aspect of the abdomen and name all the parts.

The unasternum is divided into three parts, a median field and a lateral field upon each side. The median field is much larger and more strongly chitinized than the lateral fields. This is generally what is considered as the unasternum. The large mesal pit with two openings cephalad of the unacoria is the metafurcinae. The duasternum is much broader than the median field of the unasternum. The third to sixth sterna are subequal in length. The

septasternum is much longer than the other sterna. The second to the seventh sterna are marked on each side of the meson with a carina-like irregular line. The octasternum is subequal in length to the sixth, but narrower.

Draw the ventral aspect, omitting the ovipositor, and name all the parts.

Genitalia.—Identify again the novatergum, the octaspiracles, the undatergum, the paraprocts, and the octasternum. The long bristle-like pair of appendages issuing from the caudal side of the octasternum is the octavalvae. The proximal end of each octavalva is produced internally as a parademe. The small sclerite on each side situated between an octavalva and fused to the ventral end of the novatergum is a novalatasternite. The cephalic end of each is produced internally as a parademe. The novavalvae are entirely wanting. The valvae caudad of the octavalvae are the decavalvae. The distal ends of the valvae are enlarged, sword-shaped, and more or less barbed. The lateral sclerite to which the proximal end of each decavalva is fused is a decalatasternite. The lateral end of each is prolonged into a pointed parademe. The decalatasternites are fused with the novalatasternites. The small mesal sclerite caudad of the decavalvae is the decamesasternite. Its cephalic margin is produced internally as a parademe. The undasternum consists entirely of coria. The vulva is located between the valvae.

Draw a specimen that has been split upon the dorso-meson and flattened, showing all the structures caudad of the septasegment, and name all the parts.

Eristalis Tenax.—This species has been selected because it is common and generally distributed. It is easily identified. The fact that the compound eyes are adjacent or nearly so on the meson in the male and distant in the female, readily distinguishes the sexes.

Female.—A projecting lobe of the mesonotum, the mesoscutellum, covers the unatergum in part. It is a short area, prolonged onto each lateral aspect as a small area partially separated from the mesal portion. The unacoria is long and each lateral portion bears a unaspiracle. The duatergum is longest and broadest. The third to fifth terga are successively shorter and narrower. The quitergum is quite small. It is the last exposed tergum. The terga extend as roundish areas onto the lateral aspect. The segmacoria are short. The segments are infolded, but distinct pretergites and postergites are wanting.

Draw the dorsal aspect of the abdomen and name all the parts.

The unasternum is a distinct transverse area, as long as the

unatergum. It is joined to each lateral piece of the unatergum by a narrow suture-like coria. The unacoria is long. The second to fourth sterna are subequal and similar. The quisternum is shorter and narrower. Its lateral margins converge caudad. The latacoriae are broad, especially between the terga and sterna of the second to fourth segments. The unaspiracles are located in the lateral area of the unatergum. The second to fifth spiracles are located in the latacoriae adjacent to the margin of their terga and near their cephalic margin. The exposed segments of the abdomen have been named the preabdomen.

Draw the ventral aspect of the abdomen and name all the parts.

Genitalia.—The segments caudad of the quisegment are retracted into a genatasinus. They should be fully extruded to show the long narrow pseudopositor which is formed. The terga and sterna of the retracted segments are not sharply separated. These segments have been named the postabdomen. The sexasegment is subequal in length to the quitergum. Its lateral surfaces are parallel. None of its surface is strongly chitinized. The septasegment is over twice as long as the quisegment, the cephalic chitinized portion representing the tergum and sternum and the caudal half the octacoria. There are two adjacent spiracles on each side at the cephalic margin of the septasegment, the sexaspiracles and the septaspiracles. The octasegment is similar to the septasegment, except slightly smaller in diameter. The octaspiracles are located near its cephalic margin. The novasegment is a long cylindrical segment with distinct tergum and sternum. The vulva is located in the decacoria. The shield-shaped plate caudad of the vulva is the decasternum. The decatergum is not strongly chitinized and bears a pair of one-segmented setiferous appendages, the cerci. This segment bears the anus.

Draw the ventral aspect of the pseudopositor and name all the parts.

CHAPTER VI

LEGS

The legs of insects are borne by the thorax, typically a pair to each thoracic segment. They are articulated for the most part on the ventral aspect in the coria separating the sternum and pleuron of each side, the sternacoria. While the coxacoriae have been considered theoretically as located in the sternacoria, this position is difficult to demonstrate because of the obliteration of the sternacoria or sternasuture and the fusion of the adjacent sclerites. The position of each coxacoria is more clearly indicated by stating that it is bounded on the lateral aspect by the pleuron, on the mesal and caudal aspects by the median field of the sternum, and on the cephalic aspect by the lateral field of the sternum.

The proximal segment of each thoracic leg, a coxa, is articulated against a coila, a coxacoila, which is formed typically from the cephalic sclerite of the pleuron, the episternum. The coxacoila is frequently formed, however, from a combination of both pleural sclerites, the episternum and epimeron. It is located, therefore, at one end of the pleural suture and is supported by a pleuradema. The articulatory surface of the coxa is a coxartis. The union of the coxartis with the coxacoila is generally concealed externally by a broad circular flexible area of coria, the coxacoria, which connects the coxa to the adjacent sclerites of the sternum and pleuron.

The trochantins, the pretrochantin and paratrochantin, are of considerable size in a few generalized insects. Their lateral ends articulate with or are fused with the pleural sclerites and their mesal ends articulate against the coxa. In most insects, including many generalized species, the trochantins are greatly reduced in size, usually fused into a single sclerite, which is located in the coxacoria. They have in most species lost their articulation with the pleural sclerites but have retained their articulation with the coxa. The association of the trochantins with the coxae is so close in most insects that many writers overlook the fact that they are sternal sclerites and make the mistake not only of considering but of describing them as an integral part of the leg.

The thoracic legs of insects are considered as the homologues of the first, second, and third pairs of maxillipedes of the Crustacea. They differ from these appendages in that they are not biramous.

With insects all parts of the exopodite of the crustacean appendage have been lost.

There are typically five segments in the legs of insects, the coxa, trochanter, femur, tibia, and tarsus. The number of segments varies but little and only rarely is there any question as to the homology of any given part. Each of the segments, except the distal one, the tarsus, consists typically of a single segment. While the tarsus may contain any number from one to five, depending upon the species, the most common number is five. The structure at the distal end of the tarsus bearing the claws is sometimes recognized as a sixth segment. This structure is later designated as the articularis and is apparently present in the legs of all insects. The different parts of the various segments of the legs are distinguished by the use of prefixes derived from the names of the segments, thus, coxa for coxa, trocha for trochanter, fema for femur, tibia for tibia, and tarsa for tarsus. The vowel is always elided where not needed.

The custom of applying the prefixes pro, meso, and meta, to the legs or to the sclerites of the legs, indicating the thoracic segment to which the leg or the sclerite belongs, has been followed in each case. The application of the term larvapods to the abdominal legs of larvae instead of prolegs frees this term so that it can be used for the prothoracic legs. The leg has been described as if the coxa were attached to the body and as if the portion of the leg distad of the coxa was held at right angles to the body with the sole of the foot or tarsus directed ventrad. The legs need to be treated with caustic potash to clean them and to expand the membranous parts. They should be studied in alcohol.

Coxa.—The proximal segment of the leg is the coxa. It is usually more or less globular or conical in form and joined to the sclerites of the pleuron and sternum by a broad area of coria, the coxacoria. Each coxa bears typically a single artis, the coxartis, which articulates with the coxacoila located at the ventral end of a pleural suture. In generalized insects the cephalic margin of the coxa may possess a trocartis against which a trocacoila, a coila of the trochantin, articulates. There is in addition to the two artes just named, sometimes a third one present, the sternartis, which articulates in a sternacoila in the sternellum and is consequently located on the mesal margin of the coxa. The rotation of the leg is due to the movement of the parts distad of the coxa. There is frequently present a longitudinal suture which appears to divide the coxa into two parts, but it occurs only upon one side of the

coxa. The portion upon the cephalic side of this suture to which the trochanter is articulated has been named the coxa genuina and the caudal portion the meron. This suture may be known as the alacoxasuture.

Trochanter.—The second segment of the leg is the trochanter. It is usually attached to the distal end of the coxa by a considerable area of coria, the trochacoria. The distal end of the trochanter is generally immovable. The trochanter is typically triangular in outline, at least upon one side, and the femasuture is oblique. In certain orders of insects the trochanter is subdivided into two parts by a secondary median transverse suture. The proximal portion of the trochanter is the proxatrochanter and the distal portion is the distatrochanter. The coxa and trochanter have a coila and an artis on each side of their articulation.

Trochella.—There is situated in the legs of certain insects a small chitinized sclerite in the dorsal part of the trochacoria which is known as the trochella. It may occur in one or more pairs of legs of the same insect, is sometimes a sclerite of some size, and was probably originally formed as a scuta.

Femur.—The third segment of the leg is the femur. It is ordinarily the longest and largest of the segments. The femacoria located between the trochanter and femur is almost universally reduced to an oblique immovable femasuture.

Gonycoria.—The portion of the tibiacoria located between the fematrochliae and filling the emargination of the distal end of the femora and associated with the articulation of the tibia is the gonycoria.

Patella.—The small sclerite that is occasionally present in a few insects on the ventral side of the distal end of the femur in the tibiacoria is the patella.

Tibia.—The fourth segment of the leg is the tibia. It is attached to the distal end of the femur by a broad area of coria, the tibiacoria, and frequently designated as the gonytheca. The tibia is usually shorter than the femur, but whether shorter or longer, it is generally cylindrical and much smaller in diameter. The tibia and femur have a coila and an artis on each side of their articulation.

Calcaria.—The distal end of the tibia usually bears one or more large spines, each of which is known as a calcar. The calcaria may be fixed or movable, generally movable. The distal end of the tibia, particularly among generalized insects, sometimes bears a number of spine-like setae, which are difficult to differentiate from the calcaria. In specialized insects the calcaria are always very

different from the setae and easily identified. The name of calcaria is restricted to those spine-like setae inserted within the distal end of the tibia or on the coria connecting the tibia and the tarsus, the tarsacoria. The calcaria are frequently specified in the taxonomy of insects and are usually referred to as the tibial spurs or tibial spines.

Tympanum.—Many species of Orthoptera have whitish round or oval opaque areas which are known as tympana, the external parts of auditory organs. In the Gryllidae and Locustidae the tympana are located on the cephalic and caudal surfaces of the proximal ends of the protibiae; while in the Acrididae they are the large oval areas located, one on each side, in the unatergum.

Tibiaflexis.—The femur and tibia are articulated in such a way that in order that the tibia can be folded into the fematroclia, the proximal portion of the tibia must be bent, forming a prominent femoro-tibial flexure, the tibiaflexis.

Tibiarolium.—The ventral aspect of the distal end of the tibia in certain heteropterous insects bears a transparent pad that resembles an arolium very closely but differs in that its surface is densely covered with retineriae. Such a pad is known as a tibiarolium.

Strigilis.—Many hymenopterous insects have one of the procalcaria modified, the edge knife-like or closely covered with setae. This modified calcar fits over a concave velvety surface on the proximal part of the probasitarsis. The structure formed of the basitarsis and a calcar is known as a strigilis. The antennae are drawn between the basitarsis and the calcar to remove dust and dirt.

Setigeris.—There is in certain insects, as many carabids, a structure on the protibiae which is similar in structure and use to the strigilis. This is the setigeris. It differs in that it is located upon the protibia while the strigilis is located upon the probasitarsus. A calcar and sometimes some of the adjacent setae are used for closing the depression in the tibiae, through which the antennae are drawn. The depression is often lined with short fine brush-like setae. The setae of the setigeris are usually distinctly sinuate.

Tarsus.—The fifth region of a leg is the tarsus. It is attached to the distal end of the tibia by the tarsacoria. The tarsus may contain from one to five segments, which are numbered, beginning with the proximal segment. The number of segments is reduced by specialization and in a few species the entire tarsus is wanting. The most common number of segments is five. Insects in walking apply the entire ventral surface of the terminal portion of each leg, the tarsus, to the surface over which they are moving. An exception to

this is found in the Apterygota, the larvae of insects, and a few others which apply only the end of the tarsus.

Basitarsus.—The occasion frequently arises when it is desirable to refer to the first segment of the tarsus, which is often longer than the others. This segment is designated as the basitarsus, and is also frequently called the metatarsus. With the use of the prefix meta to designate parts of the metathorax, confusion is likely to result and the term basitarsus which has been offered as a substitute has been adopted. This term can be applied to the first tarsal segment of any of the legs without ambiguity.

Plantella.—The distal end of the distal tarsal segment is sometimes prolonged on the ventral side into a long median projection, a plantella. This projection may be blade-like, as long as the claws, and evidently assumes the function of the planta when this structure is wanting.

Troclia.—The distal end of any segment of the leg may be enlarged on one or both sides into a plate or flange for producing a more perfect articulation. Such plates are of more common occurrence on the femora than elsewhere. Each plate is known as a troclia and its position can be designated by the use of the abbreviation of the name of the segment.

Sulci.—The various segments may be furrowed or hollowed out on one or both sides so that the segment attached to the end bearing the furrow can be folded into the furrow like the blade of a knife into its handle. Such a furrow is known as a sulcus. They are very prominent in those insects that fold their legs tightly together and feign death. By applying the abbreviation of the name of the segment its position can be designated, thus, coxasulcus, femasulcus, etc.

Articularis.—The structure borne at the distal end of the distal segment of the tarsus is the articularis. It is always disregarded, except for one or two prominent parts, the claws and the tulilli, in the descriptions of insects. Most morphologists consider these structures as an integral part of the distal tarsal segment, a few of the older authors regarded them as an additional segment. The name of praetarsus has been applied to this region in certain arthropods, but it is a misnomer at best, for the articularis is in reality a posttarsus. The term praetarsus has, consequently, not been adopted. The greater part of the articularis is retracted within the end of the distal tarsal segment and in great part concealed, but is, so far as observed, always present. In specialized insects where the tarsi are greatly modified through the development of accessory parts, the articularis may be very complex in structure. In order

to be able to identify all the parts of the articularis, it should be separated from the tarsus.

Tubercula.—The dorsal side of the distal end of the distal segment of the tarsus is infolded or thickened or both and bears projections or emarginations against which the claws and orbicula articulate, the tubercula. It is an associated part of the articularis and varies greatly in size, form, and distinctness in different species.

Claws.—The long more or less hooked structures located on each side of the articularis are the claws. They are also known as tarsal claws or ungues. The dorsal part of the proximal end of each claw is condyle-like in form and articulates against the tubercula while the ventral side of the proximal end articulates against an auxilia or, when this is wanting, against the side of the planta. The claws vary greatly in form due to the amount they are hooked, they also vary as to whether they are toothed or not. Each claw may be divided into two equal or nearly equal parts when they are said to be cleft, in which case the two rays of each claw may be equal or the outer ray longer or shorter than the inner. The ventral concave margin may bear one or more erect teeth when it is said to be toothed or may bear a large number of teeth when it is said to be serrate or the proximal shoulder may be produced as a tooth when the claw is said to be appendiculate.

Retineria.—The microscopic seta-like projections on the ventral surface of the tarsi are the retineriae. They are the sessile pores or hollow seta-like projections from which is poured the sticky or adhesive substance which aids the insect in maintaining its position on vertical polished surfaces. They are sometimes called tenent-hairs, which are considered as synonymous with digitules.

Digitules.—The distal end of the distal tarsal segment and the proximal part of the claws may bear long slender setae that are clavate at the distal end. These setae are known as digitules, also as tenent hairs or empodial hairs. It is supposed that a sticky substance is poured from the open ends of the digitules, which aids the insect in clinging to surfaces. The digitules on the tarsi are distinguished as the tarsal digitules and those on the claws as the ungual digitules. The number of tarsal or ungual digitules occurring in any individual is about two to four, in rare cases there may be a considerable number. The digitules are of more general occurrence in minute insects like the collembolans and the males of coccids.

Orbicula.—The chitinized area situated on the dorsal aspect of the articularis is the orbicula. It is ordinarily located between the claws and generally articulates against the tubercula. The

orbicula is frequently fused with the membrane of this region and is not distinguishable as a separate sclerite.

Calcanea.—The plate situated on the ventral side at the proximal end of the articularis is the calcanea. It is usually concealed externally for the most part through its retraction into the distal end of the distal tarsal segment. The tendon operating the articularis, the artatendon, is attached to the proximal end of the calcanea. It is very long and slender and extends through the tarsus and tibia.

Planta.—The small chitinized plate situated on the ventral side of the middle of the articularis at the distal end of the calcanea is the planta. It is sometimes fused with the calcanea and frequently with the auxilia.

Auxilia.—The small sclerite located on each side of the ventral aspect of the articularis distad of the calcanea is an auxilia. They may be greatly reduced in size, wanting, or fused with the planta.

Tulillus.—The different segments of the tarsus may contain pads which are of use to the insect in maintaining its position on various surfaces, particularly those that are smooth and polished. These pads vary greatly in form and structure in different species. They are inflated cushion-like structures in certain insects, in others they are masses of setae of various kinds, while in others they are open setae that exude an adhesive substance. The term pulvillus should be used here in a generic sense, but this name is so firmly associated with structures occurring in the feet of dipterous insects that there was no hopes of using it in any other sense. The name tulillus, meaning a little pad, has been used instead.

Arolium.—The membranous pad-like tulilli found on the ventral side of the segments of the tarsi and at the distal end of the articularis are the arolia. They are frequently called pulvilli. The arolia are usually glabrous pads or bags and are of common occurrence in orthopterous insects. The arolium at the distal end of the articularis is frequently very large and often referred to as "the pulvillus." It may be known as the artarolium.

Pulvilli.—The pair of flat cushion-like tulilli or pads located ventrad of the claws are known as the pulvilli. They are sometimes called onychii, but this name like that of pulvilli is frequently applied to structures very different from the pair of pads found in dipterous insects. The ventral surface of each pulvillus bears numerous retineriae from which exudes a sticky fluid that enables the insect to walk on various surfaces, as vertical polished surfaces or on the lower surface of objects, like a ceiling. The name of pulvilli has been restricted to the tarsal cushions of the Diptera.

They arise as direct prolongations of the coria closing the distal end of the fifth tarsal segment.

Empodium.—The flat cushion-like pad located between the pulvilli in many dipterous insects is known as an empodium. They are typically similar in form and structure to the pulvilli, but are reduced in many flies to a mere knob bearing setae.

Arolella.—There is a peculiar type of tulillus found in many hemipterous insects. It is very similar to an arolium in many respects and has been given this name by certain writers. Each is attached, however, to a claw and not between the claws. This structure is an arolella. The bladder-like portion is sometimes attached to a minute proximal sclerite, the ungulis.

Arolanna.—The tulillus found upon the articularis in hymenopterous insects resembles the arolella of hemipterous insects very closely. They are delicate, usually transparent structures supported by the orbicula and camera and are known as arolannae. They occur elsewhere than in the Hymenoptera.

Aroloidea.—The coria at the distal end of the tarsal segments in certain hemipterous insects is swollen bag-like, forming tulilli. These are known as aroloidea.

Onychium.—The distal end of the calcanea in most dipterous insects is prolonged into a long slender spine-like projection. Such a projection is known as an onychium. The students of flies usually state when an empodium is present that it is pulvilliform and when an onychium is present that it is spine-like or wanting. There is absolutely no reason for considering the empodium and onychium as homologous structures. An onychium is also present in certain beetles, where it may be of considerable length and bears long setae at its distal end. In the Coleoptera these setae are known as the paronychium.

Camera.—The curved band of cuticle extending from the ventral aspect onto the dorsal aspect and serving as a support for the proximal end of a tulillus, artarolium and arolanna, is a camera.

Solea.—The tulilli occurring on the ventral side of the tarsal segments and consisting of patches of numerous retineriae bounded by short curved fringing setae are known as soleae. They are of common occurrence among coleopterous insects.

Pulvicoria.—The coria of the distal tarsal segment on each side of the tubercula is sometimes produced as a long slender tail-like lobe, as long as a claw, along the outer side of the claws. Each of these lobes is known as a pulvicoria. They are sometimes pectinate.

Pulvinis.—The ventral surface of several, usually the four

proximal, segments of the tarsi are densely or sparsely covered with retineriae, forming tulilli as in the males of many beetles. The mass of retineriae found on each segment in such cases is known as a pulvinis. Such structures are not limited to the tarsi of beetles.

The different legs are variously modified to fit them for a particular use. The legs in cursorial species, which group includes a very large proportion of the species of insects, the proximal articulations are freer, because a freer movement is needed for walking and running than in those species where the legs are used as oars for swimming, which requires a rigid appendage capable of a free backward and forward movement. In other insects the legs may be elongated or widened to give room for the attachment of the strong muscles used in jumping. The prolegs in certain species have certain parts modified, hand-like or spoon-like, fitting them for burrowing or scratching or for moving the soil, while in another group the prolegs have the various segments elongated or thickened and modified into organs for grasping and holding prey. The various legs studied have been divided into groups according to the way in which they are used: 1. Ambulatory Legs; 2. Natatorial Legs; 3. Fossorial Legs; 4. Saltatorial Legs; and 5. Raptorial Legs.

1. AMBULATORY LEGS

The number of species of insects provided with legs for walking or running outranks all the other groups put together. The different pairs of legs may be modified for various purposes. The prolegs may be fitted for digging or burrowing or for grasping while the other pairs are fitted for walking. Likewise, in those insects where the metalegs are fitted for jumping, the prolegs and mesolegs are coordinated with the metalegs and fitted for walking. In insects with the legs fitted for walking or running, the prolegs, when in use, are directed forward, the mesolegs outward and slightly backward, and the metalegs backward. The prolegs are usually shorter than the others and probably function to drag the body along, the mesolegs are intermediate in length between the prolegs and the metalegs and support the body, the metalegs are usually longest and serve to push the body forward. Because of the difference in the size of the legs and the way in which they are directed, the shape of the proximal segment and the length of other parts are different in each pair.

Blatta Orientalis.—Study a mesoleg. The coxa is irregular oval in outline, depressed. The proximal end is emarginate. The

cephalic indentation is the coxartis and the caudal the trochartis. There is a broad coxasulcus on the ventral aspect, limited on one side by a thin flange and on the other by a curving suture extending from near the coxartis to near the distal end. The prominent flange at the distal end near the suture is the coxatroclia. The coxasulcus is finely striate like a radula. The suture forming the boundary between the coxa genuina and meron is distinct. The trochanter is triangular in outline, the femasuture is immovable and oblique. There is a constriction between the femur and trochanter. The femur is subcylindrical with a prominent ventral femasulcus, each margin of which bears a row of stout setae. Each side of the distal end is produced into a slight fematroclia. The tibia bears large irregularly arranged spine-like setae inserted in circular or oval depressions. The tibiaflexis is not prominent. The dorsal half of the distal end is produced hood-like, forming a coila for the articulation of the tarsus. The tarsacoria bears three long conical calcaria. The tarsus consists of five segments, the basitarsus is much the longest and bears a double row of short setae on the ventral aspect. The distal end of the first to fourth segments are oblique, the ventral portion is prolonged and modified into an arolium, guarded on each side by a minute short stiff seta. The claws are long and bluntly pointed, only slightly curved, and with a slight tooth on the ventral side at the proximal end. The arolium of the distal segment, the artarolium, which is located between the claws, is globular.

Draw the caudal aspect of a mesoleg and name all the parts.

The dorsal side of the distal end of the fifth tarsal segment is infolded to form a tubercula. It contains three emarginations. The small artis-like proximal end of a claw articulates in each outer emargination. The plate located on the arolium between the claws and articulating against the median emargination of the tubercula is the orbicula. The calcanea is the largest area of the articularis, shield-shaped, with two broad oblique emarginations at the distal end. Each subquadrangular plate articulating in an emargination of the calcanea is an auxilia. The distal end of each auxilia is emarginate. The ventral side of a claw articulates in the emargination. The slightly chitinized area between the auxiliae and bearing a stout seta is a planta. The artatendon is long and slender.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Melanoplus Differentialis.—The prolegs and mesolegs are of the ambulatory type, the metalegs of the saltatorial type. Study a proleg. The coxae are subcylindrical. There is a short longi-

tudinal furrow on the cephalic side. The black spot near the proximal end of this furrow is the coxartis. The prominent triangular projection at the distal end of the coxa is the coxatroclia. The trochacoria is distinct, broad on the dorsal side. The femacoria is immovable. The trochanter is typical in form and the distal end is oblique. The femur is elongate, slightly bowed, and without a femasulcus. The distal end is provided with two large fematrocliae. The tibia is as long as the femur. The distal half of the ventral aspect bears a double row of black setae. The tibiaflexis is practically wanting. Each side of the distal end is modified into a slight tibiatrochlia. The calcaria are wanting. The tarsus consists of three segments. The first segment is long with a median dorsal ridge. The distal end is oblique in which is inserted the short oblique second segment. The third segment is elongate, subcylindrical, bowed, and enlarged at the distal end. The claws are short, hooked, distinctly widened at the proximal end. The arolia are prominent, three on the basitarsis. Those of the first and second segments with a median furrow. The arolium of the third segment is long and slender. The artarolium is like a large flattened bag.

Draw the caudal aspect of a proleg and name all the parts.

The tubercula is an angular projection with each side emarginate. The condylar end of a claw articulates in each emargination. The orbicula is short and membranous. The calcanea is shield-shaped, the proximal end rounded, the distal end truncate. The artatendon is long and prominent. The subquadrangular area adjacent to the distal end of the calcanea is the fused auxiliae. The distal half of each lateral margin is emarginate. The ventral side of the proximal end of a claw articulates in the emargination. The chitinized blackish band extending around the margin and on the proximal end of the artarolium is a camera. On the ventral aspect it articulates against the auxiliae and the dorsal emargination fits over the tubercula. The dorsal surface of the artarolium is setiferous.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Gryllus Pennsylvanicus.—The prolegs and mesolegs are of the ambulatory type, the metalegs are of the saltatorial type. Study the setiferous proleg of a female. The coxa is somewhat vase-shaped, attached obliquely, the proximal portion constricted. The distinct indentation in the lighter colored part of the proximal end is the coxartis. There is a trocartis on the cephalic margin in which a trochantin is articulated. The longitudinal furrow near the middle of the caudal aspect terminates in the rounded area filled

with trochacoria. The coxatrocliae are large, the one on the caudal side, spine-like. The trochanter is knuckle-shaped, the distal end broad and flaring. The femur is compressed. The fematrocliae are at most only feebly indicated. The femafossa is prominent, glabrous, its margins lined with setae. The tibia is shorter than the femur, bears setae of two lengths. The large oval white area on the caudal aspect of the proximal portion of the tibia and the much smaller but similar one on the cephalic aspect are the tympana. The tibiaflexis is distinct. The distal end of the tibia bears three large calcaria and is provided with two small tibiatrocliae. The tarsus consist of three segments. The second segment is short and oblique, the others are much longer. All the segments bear one or two rows of short black setae along each margin of the ventral aspect. Tulilli are wanting. The claws are short, sharply pointed, not strongly hooked, the dorsal margin setiferous. Each has a single long seta inserted near the proximal end of the ventral margin.

Draw the caudal aspect of a proleg and name all the parts.

The tubercula is the slight angular prominence against which the angular knob of the dorsal side of the proximal end of the claw articulates. The orbicula is represented by coria. The calcanea is shield-shaped, the proximal portion, to which its tendon is attached, is rounded. The distal end is produced, spine-like. The planta is obsolete. The auxiliae are fused and articulate against the calcanea. The distal portion of the proximal margin of a claw articulates in the emargination. The distal angles of the auxiliae project over the claws.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Libellula Pulchella.—The legs differ only in the shape of the coxae. Study a proleg. The coxae are irregular. The lateral surface and the mesal ridge are densely setiferous. The coxartis is the indentation on the cephalic side of the proximal end of the lateral aspect. The two coxatrocliae are small and the trochanter is elongate. A constriction divides the trochanter into unequal proxatrochanter and distatrochanter. The fesmasuture is oblique and immovable. The femur is flattened. There is femasulcus with rows of spine-like and long slender setae on each side. The fematrocliae are small. The tibiae are slender, subcylindrical. The titbiaflexis is obsolete. Each side of the ventral margin bears setae, one side long and the other short and stout. The calcaria are wanting. The tarsus consists of three segments, the distal longest and the proximal shortest. The ventral surface of the segments bears rows of stout setae. Tulili are wanting. The claws are long.

slightly curved, not hooked, with an erect tooth on the ventral margin near the distal end.

Draw the caudal aspect of a proleg and name all the parts.

The median part of the distal end of the ventral aspect of the third segment is prolonged as a bluntly pointed plantella. There is an emargination on each side adjacent to the plantella in which a claw fits. The tubercula is a minute quadrangular projection with an acetabulum between each lateral margin of the tubercula and the end of the tarsal segment in which a claw articulates. The orbicula is represented by a narrow area of corea. The calcanea is a long shield-shaped area. The proximal end is bluntly rounded. The fused auxiliae are represented by an inverted vase-shaped area, which projects between the claws. Each concave side of the auxilia forms an acetabulum for the ventral side of the proximal end of a claw.

Draw the dorsal aspect of the articularis and name all the parts.

Draw the ventral aspect of the articularis and name all the parts.

Leptinotarsa Decemlineata.—The three pairs of legs are similar. The metacoxae are different in form and size from the others, they also lack trochantins. Study a metaleg. The coxae are transverse. The trochanter is joined to the coxa near the mesal end. The indentation in the mesal end of the coxa is the sternartis. The coxartis is situated at the lateral end. The metacoxae of this insect are typical for the order. The ventral surface is provided with a distinct transverse coxasulcus. There is a coxatroclia on the cephalic side. A slit extends from the caudal side of the trochacoria to the margin of the coxa. The coxa and trochanter articulate as a ball and socket joint. The femasuture is oblique. The femora are stout and swollen. There is a slight femasulcus. Fematrocliae are present. The tibia is gradually dilated to the distal end. The tibiaflexis is very prominent. The tibiatrocliae are prominent, forming an emargination on the dorsal side against which the tarsus is folded. The tarsus consists of five segments. The segments are all different in form and size. The fourth segment is minute, globular, immovably fused with the proximal end of the fifth, and articulates in the dorsal surface of the third. There are prominent soleae on segments one to three. A tulillus is lacking on the distal segment. The claws are sickle-shaped and pointed.

Draw the caudal aspect of a metaleg and name all the parts.

The tubercula consists of two minute obliquely truncate quadrangular projections with a slight mesal emargination. The orbicula is membranous. The calcanea is flask-shaped. The artatendon

is prominent. The auxiliae are wanting. The plantella is produced between the claws with an emargination on each side against which the claws articulate.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Euschistus Variolarius.—The legs are all similar in form. Study a mesoleg. The coxa is inserted in an oblique coxacava. It is horizontal in position, the trochantin is articulated to the cephalic side of the coxa. Its proximal end is truncate, forming a coxartis. The trochanter is elbowed. The femora is long and cylindrical. The fematroclia and the femasulcus are wanting. The tibiaflexis is almost wanting. The tibia is cylindrical and setiferous. The calcaria are wanting. The tarsus consists of three segments, the second is the shortest. Each side of the ventral aspect of each segment has a fringe of long setae. The second and third segments lack tulilli. The claws are small and sickle-shaped. The arolellae are prominent and bladder-shaped, each is attached to a quadrangular ungulis. The two long setae between the claws are borne by the fused auxillae.

Draw the caudal aspect of a mesoleg and name all the parts.

Tabanus Sulcifrons.—The legs are all similar. Study a mesoleg. The coxae are transverse and subadjacent. Each is shaped like an inverted scoop. The coxartis is located at what would be its tip, the trocoila is located at the handle end, the mesal. There is a blunt spine-like coxatroclia on the caudal side articulating in a notch in the trochanter. A similar but much smaller projection on the cephalic side articulates in a different notch. Along the caudomesal margin there is a distinct cleft. The trochanter is elongate, irregular in outline. The femasuture is immovable. The femur is cylindrical and setiferous. The fematrocliae are distinct. The tibia is setiferous and lacks a tibiflexis. The ventral part of the distal end is emarginate with two small calcaria inserted in the emargination. The tarsus consists of five segments. The basitarsis is about as long as the other four segments together. The ventral surface and the distal ends of the segments bear short spine-like setae. The distal end of segments one to four is emarginate, the fifth segment is cordate and bears long setae on the dorsal aspect. Tulilli are wanting on the tarsi. The claws are slender and strongly curved. The empodium and the pulvilli are large and similar in size.

Draw the caudal aspect of a mesoleg and name all the parts.

The dorsal part of the distal end of the fifth tarsal segment is

folded ventrad with a small stout Y-shaped tubercula on its ventral margin. The dorsal corner of a claw articulates against each arm of the Y. There is no ventral articulation of the claw. The orbicula is membranous. The calcanea is broadly triangular with a stout artatendon attached in an emargination in the proximal end. The flattened truncate lobe continuous with the distal end of the calcanea is the empodium. Its ventral surface bears retineriae. The pulvillus on each side of the empodium is similar in form and also bears retinariae. Each pulvillus is borne by an auxilia, a short transverse sclerite attached to the lateral portion of the distal end of the calcanea. The auxiliae extend onto the dorsal aspect where each forms a narrow area fused with the coria of the distal end of the tarsus.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Promachus Vertebratus.—The legs are similar except in size. Study a proleg. The coxae are cylindrical, elongate and the distinct notch in the proximal elongation is the coxartis. The coxatrocliae are prominent. The trochanter is subtriangular and the femur is short and stout. The fematrocliae are flaring. The tibia is cylindrical. The tibiaflexis is not prominent. Calcarae are wanting. The tarsus consists of five short segments. The femur, tibia, and tarsus bear numerous stout black and long slender setae. Each segment of the tarsus bears a solea. The claws are long and stout with a blunt tooth. The pulvilli are large flattened pads and the onychium is a stout spine.

Draw the caudal aspect of a proleg and name all the parts.

The tubercula is the median projection which is deeply roundly emarginate at middle, appearing like two projections. The single articulation of the proximal end of the claw is against one of these projections. The orbicula is membranous. The calcanea is large, shield-shaped. The proximal end is emarginate with a strong artatendon attached in the emargination. The onychium is long and spine-like. The distinct area articulating against each latero-distal portion of the calcanea is an auxilia. Each bears a long truncated pad, nearly as long as a claw, a pulvillus. The ventral surface bears retineriae. The auxiliae extend onto the dorsal aspect as distinct plates, and fuse. From the distal margin of each auxilia two distinct parallel brownish plates extend nearly to the distal end of the pulvillus.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

VESPA MACULATA.—The legs are all similar. Study a mesoleg. The coxa is subconical. The protuberance on one side of the proximal end is the coxartis. The coxatrocilae are very small. The trochanter consists of two segments. The dumb-bell-shaped proxatrochanter is large, the small distatrochanter is concealed by the overlapping end of the proxatrochanter. It is fused to the femur. The femur is subcylindrical, the fematrocliae are small. The tibia is dilated distad. The tibiaflexis is not prominent. There are two bowed calcaria, the cephalic much the shortest, the caudal half the length of the basitarsis, with its ventral surface densely setiferous. The tarsus consists of five segments. The basitarsis is nearly as long as all the others together. The proximal one-fourth of the basitarsis is bowed, its ventral surface is densely setiferous, forming with the caudal calcar a strigilis. Tulilli are wanting on the tarsus. The claws are short, strongly hooked. The arolanna is prominent.

Draw the caudal aspect of a mesaleg and name all the parts.

The tubercula is a transverse plate with its angles sharply produced. The single articulation of each claw is made against one of these angles. The orbicula is an elongate plate. The proximal end is oval in outline and bears two setae as long as the articularis. The orbicula articulates against the tubercula. Its distal end is emarginate with rounded corners bounding the emargination. There is a triangular area inserted in the emargination. The calcanea is shield-shaped, the proximal end emarginate with an artatendon attached in the emargination. There is a round notch in each corner of the distal end in which a small round auxilia is located. The transverse setiferous bar distad of the calcanea is the planta. The arolanna is large, U-shaped as seen from the dorsal aspect, and supported on this aspect by a blackish ribbon-like band, the camera. The claws are densely setiferous. There is a single large seta on the ventral side of the proximal end.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

APIS MELLIFERA.—The legs are especially fitted for combing out the grains of pollen collected by the pectinate setae of the body. The proleg has a highly developed strigilis. The metalegs are modified for carrying pollen. Study a metaleg. The coxa is pyramidal. The coxartis is distinct. The coxatrocilae are small. The trochanter is elongate. The femasuture is immovable. The femur is subcylindrical. The fematrocliae are small. The tibiaflexis is wanting. The coxax, trochanter, and femur bear numerous long pectinate setae. The tibia is strongly compressed, the distal end much broader than the proximal. The caudal surface is con-

vex and setiferous; the cephalic concave, almost glabrous, and margined by a row of long curved setae, forming a corbel for holding pollen. The dorsal two-thirds of the distal end is furrowed and fringed with stiff setae. The calcaria are wanting. The tarsus consists of five segments and the basitarsis is quadrangular, strongly compressed, nearly as long as the tibia. The dorsal part of the proximal end is modified into a lobe fringed with setae and fitting in the tibia. The cephalic surface is convex and sparsely setiferous. The caudal surface is densely setiferous, the setae stout, oblique, arranged for the most part in nine rows. Tulilli are wanting on the tarsus. The claws are short, broad, and stout. Each bears a stout tooth on the ventral surface. The arolanna is small.

Draw the caudal aspect of the metaleg and name all the parts.

The tubercula is short and broad, broadly concave at middle, the concavity bounded by sharp angular projections. The single articulation of the claw is against one of these angular projections. The orbicula is spindle-shaped. The proximal end articulates against the tubercula and bears six or more large setae. The distal portion is narrow. The calcanea is subquadrangular, the proximal end is angularly emarginate. The distal end is a bluntly pointed projection, emarginate on each side of the projection. There is a small auxilia associated with each of these emarginations. The broad convex densely setiferous area at the distal end of the calcanea is the planta. The camera is a broad semicircular black band. The claws are cleft. The ventro-proximal portion of each claw bears a large seta and several small ones on the dorsal surface. The arolanna is furrowed on the dorsal aspect.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Feltia Jaculifera.—The legs are densely scaly. Study a proleg. The coxae are elongate, spindle-shaped. The truncate longer portion of the proximal end is the coxartis. Coxatrocliae are wanting. The trochanter is bowed. The femasuture is short, immovable and the femur is short, subcylindrical. Fematrocliae are wanting. The tibia is very short, enlarged at distal end. The dorsal surface bears two rows of stout spine-like setae. The ventral aspect is deeply emarginate. The emargination is filled with coria and bears near the middle of the tibia a greatly swollen lobe, the single calcar. The adjacent surfaces of the calcar and tibia are velvety setiferous, forming a large strigilis. The tarsus consists of five cylindrical segments, the basitarsis longest. The ventral surface bears two rows of short stout setae. Tulilli are wanting on the

tarsus. The claws are short, strongly hooked, and unequally cleft. The arolanna is small.

Draw the caudal aspect of a proleg and name all the parts.

The tubercula is a small quadrangular projection. The narrow linear area between the claws is the orbicula. The pulvacoriae are large. Each rests upon the proximal part of a claw and is fringed by a number of fine pectinations. They are sometimes so closely applied to the claw that they look like setae. The calcanea is four-sided, slightly longer than wide, emarginate at the proximal end for the insertion of the artatendon. The suboval area near the distal end of the calcanea is the planta. The proximal part of a claw articulates against each side. The auxiliae are wanting. The arolanna is U-shaped on the dorsal aspect and supported by a ribbon-like camera, which connects on each side with a plate extending to the distal end.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

2. FOSSORIAL LEGS

An indication of the fossorial habit is shown by an enlargement or widening of the protibiae, modification of their margin into a cutting edge and of this edge into teeth, also a strengthening of the calcaria and often of their dilation into spoon-like structures. Many species, known as running insects, also have the first pair of legs modified for moving soil. As the legs become more and more modified for digging, the mesolegs and metalegs are modified for moving the loosened material away from beneath the body and out of the way of the prolegs.

Harpalus Caliginosus.—Study a proleg of a female. The coxae are inserted in coxacavae. Each coxa is conical. The minute quadrangular sclerite of the proximal end is a trochantin and the indentation near it is the coxartis. The distal end is reduced in size. The coxatrocliae are small. There is a broad coxasulcus extending between them. The trochanter is constricted at middle. The femasuture is immovable. The femur is club-shaped. The ventral margin bears two rows of long setae. The fematrocliae are prominent. There is a quadrangular patella located in the gonycoria. The tibia is greatly enlarged toward the distal end. The tibiaflexis is distinct. The ventral surface on each side bears a fringe of short stout setae. There are two calcaria. One is attached to the distal end and the other near the middle of the ventral aspect. There is an oblique groove fringed with setae leads under this latter calcar, forming a setigeris. There are three long slender

sinuate setae that form a part of the setigeris. The distal calcar is long, curved, and pointed. It is fitted for digging. The tarsus consists of five segments, the distal segment longest, the others cordate. Each side of the ventral surface of each segment bears a row of stout setae. None of the segments are broader than long. The claws are slender, sharply pointed, and curved. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.
Draw the ventral aspect of a protarsus and name all the parts.

Study the protarsus of a male. Segments one to four are distinctly broader than long, cordate and each margin of each of these segments is fringed with long slender setae. Its ventral aspect bears on each side an oblique row of long closely placed white retineriae, forming pulvines. Such tarsi are said to be dilated and biserately squamulose.

Draw the ventral aspect of a protarsus and name all the parts.

Study the articularis of the female. Each side of the distal end of the fifth tarsal segment is emarginate, forming depressions in which the claws are retracted. The plantella is a broad thin bluntly rounded plate. The tubercula is quadrangular, a claw articulating against each distal angle. The orbicula is membranous. The calcanea is quadrangular with rounded corners. The auxiliae are wanting. The long linear plate at the distal end of the calcanea and projecting between the claws is the planta.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Triplectrus Rusticus.—Study a proleg of a female. The coxa is globular and located in a coxacava. The coxartis is situated near the trochantin. The coxatrochliae are not prominent. There is a slight coxasulcus and the trochanter is triangular and the femur is strongly thickened. The fematrochliae and patella are distinct. The tibiaflexis is not prominent. The tibia is gradually dilated toward the distal end. The ventral surface bears a single row of short stout setae. There are two calcaria, a triradiate one at the distal margin, which is fitted for digging, and a long simple stout one on the ventral aspect associated with an oblique furrow fringed with setae. There are two long sinuate setae associated with this furrow to form a setigeris. The distal margin also bears a few stout setae. The tarsus consists of five unequal segments, segments one to four have stout setae on each side near the distal end and a median ventral peg-like spine. The claws are slender, curved, and blunt. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.
Draw the ventral aspect of a protarsus and name all the parts.

Study the protarsus of a male. The first to fourth segments are cordate, much broader than long. The margin of each segment bears three to seven curved setae. The ventral surface of the first to the fourth segments bear large pulvines with retineriae arranged in rows. The claws are short, stout, and straight. Such tarsi are said to be dilated and spongy pubesecent beneath.

Draw the ventral aspect of a protarsus and name all the parts.

Scarites Subterraneus.—The prolegs are modified for digging and the mesolegs and metalegs are widened for passing soil. The coxae are located in coxacavae. Study a proleg. The coxa is globular. The coxartis is located near the small trochantin. The coxatrocliae are prominent. The coxasulcus is broad. The trochanter is deeply constricted. The femur is stout and subcompressed. The caudal surface is convex and bears a few long slender scattered setae. The patella is large. The fematrocliae are small. The tibiaflexis is present. The tibia is strongly dilated toward the distal end. The margin is modified into two large and two or three small tooth-like projections. There is a similar but much larger one at the distal end. The tibia is distinctly of the fossorial type. There are two calcaria, one at the distal end, curved tooth-like, the other on the caudal aspect near the ventral margin is folded over an oblique seta lined furrow. There are also two sinuate setae project over this furrow, forming a setigeris. The caudal surface is roughened by protuberances. There are setae on the caudal and cephalic aspects. The tarsus consists of five cylindrical segments, the basitarsis longest. There is a row of stiff setae on each margin and around the distal end of the four proximal segments. The claws are long, slender, not strongly curved. Tulilli are wanting.

Draw the cephalic aspect of a proleg and name all the parts.

Lucanus Dama.—The coxae are situated in coxacavae. The mesolegs and metalegs are only slightly modified. Study a proleg. The coxa is strongly transverse. The trochanter is articulated to its mesal end. The coxatrociiae are very large. The trochanter is in great part concealed by the coxatrocliae. The femur is long, stout. The patella and fematrocliae are large. The tibiaflexis is not prominent. The tibia is compressed, the distal portion expanded, the cephalic aspect convex, and the caudal concave. The dorsal margin is a thin cutting edge modified into three or four teeth, the two at the distal end large and adjacent. There is a single curved calcar on the ventral side of the tarsal articulation. The tarsus consists of five segments, the fifth longest. Each side

of the ventral aspect of segments one to four bears a band of pulvines. The retineriae are longest toward the distal end. The claws are long, strongly hooked. The onychium is prolonged between the claws as a long slender projection bearing a paronychium.

Draw the cephalic aspect of a proleg and name all the parts.

The articularis is retracted in the distal end of the tarsus. A broad rounded convex plate formed from the ventral aspect of the distal end of the tarsus projects over the claws. The tubercula is a prominent transverse plate against which the large globular proximal end of each claw articulates. The linear elongate plate situated between the claws, concealed by their convexity, is the orbicula. It serves as a place of articulation for each claw. The calcanea is shield-shaped, longer than broad. The auxiliae are wanting. The onychium is prolonged as a long slender subcylindrical bent projection between the claws, reaching nearly to their distal ends. The distal portion is swollen and the distal end is angularly pointed, each side of the obliquity bears long slender setae, a paronychium. The projection is the onychium and the setae the paronychium of coleopterists.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Geopinus Incrassatus.—The mesolegs and metalegs are modified for moving material, the prolegs for digging. Study a proleg. The coxae are globular. The coxartis is located near the trochantin. The coxatrocliae are small. The trochanter is triangular. The femur is stout, subcompressed and the patella and fematrocliae are present. The tibiaflexis is small. The tibia is dilated toward the distal end. Both margins and the distal end are fringed with short sharp setae. The dorsal half of the distal end is produced on the caudal side into an oblique flap-like scraper which is fringed with sharp spine-like setae. There are two calcaria, the one at the distal end is stout, blunt, and curved. The other is located on the caudal aspect over a setiferous furrow, forming with the furrow and two sinuate setae a setigeris. The tarsus consists of five unequal setiferous segments. The claws are long, slender, and pointed. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.

Lachnosterna Hirticula.—The mesolegs and metalegs are provided with rings of setae for moving soil. Study a proleg. The coxa is elongate, transverse, and cylindrical. The coxartis is located at the lateral end, the trochantin near it. The coxatrocliae are large. The trochanter is small. The femur is short and stout,

with rows of long slender setae. The fematrocliae are large, the tibiaflexis is almost wanting. The tibia is compressed. The dorsal margin is triemarginate, forming two teeth, and a large blunt flat distal tooth projecting some distance distad of the tarsal articulation. There is a single calcar attached on the caudal aspect near the distal end of the ventral margin. The ventral margin and the distal end bears long slender setae. The tarsus consists of five segments with their distal ends enlarged. The claws are short, strongly curved, with a large erect median tooth. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.

The tubercula projects distad as a quadrangular area with the distal end angularly emarginate. The orbicula is membranous. The calcanea is oval in outline with a median ridge. The distal portion is constricted. This portion bears at its distal end an oval area, the onychium, which projects between the claws. The onychium bears two divergent setae, each extending beyond the claws. The auxiliae are wanting.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Bembex Fasciata.—The prolegs are fitted for digging in sand. Study a proleg. The coxa is pyramidal, one side swollen. The coxartis is on the swollen side. The coxatrocliae are small and the coxasulcus is prominent. The trochanter is large. The proxatrochanter is the large piece generally considered as the trochanter. The distotrochanter is a small exposed ring attached to the femur. The femur is subcylindrical, the proximal portion swollen. The fematrocliae are small. The tibiaflexis is fairly distinct. The tibia is short and cylindrical. The caudal margin bears a row of six short setae. There are two calcaria. One is long and slender, the other of the same length, but is bifurcate at the distal end, flattened, hand-like. The tarsus consists of five segments. The basitarsis is elongate, the caudal margin bears six long erect clavate setae, which are successively longer caudad. There is a rounded setiferous notch in the proximal part of the cephalic margin in which the flattened calcar fits, forming a strigilis. The cephalic margin of the first to fourth segments is fringed with short setae. The caudal margin of the second to fourth tarsal segments bears two long clavate setae. These setae form a rake for moving sand. The fifth segment lacks the flattened setae. The claws are long, slender, pointed, and comparatively straight. The arolanna is large, U-shaped on the dorsal aspect.

Draw the caudal aspect of a proleg and name all the parts.

Gryllotalpa Borealis.—The prolegs of this insect are especially well fitted for moving soil. The mesolegs and metalegs are not markedly modified. Study a proleg. The coxa is irregular in outline. The coxartis is a small globular area. The coxatrocliae are very large. The trochanter is completely surrounded by the coxatrocliae and two troclia-like projections on the femur and is practically immovable. The femur is compressed, nearly as broad as long. The fematrocliae are large, holding the tibia vise-like. The femasulcus, extending between the fematrocliae, is deep, bounded on one side at the proximal end by one of the troclia-like plates. The tibia is greatly dilated and compressed. The tibia bears four long stout finger-like projections. The two dorsal projections are movable calcaria and the two ventral are immovable teeth. The curved slit-like structure on the cephalic aspect cephalad of the fematroclia is the external opening of a tympanum. In other genera the tympanum is an exposed white oval membrane. The tarsus consists of three segments. It is articulated to the caudal aspect of the tibia near the proximal end of the ventral calcar. The proximal segment is a large triangular tooth; the second segment is similar in form but much smaller, and the third segment is small and cylindrical. The claws are small, curved, adjacent. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.
Draw the cephalic aspect of a proleg and name all the parts.

3. NATATORIAL LEGS

The natatorial or swimming type of leg is characteristic of most insects that live in the water. The modification consists either in a widening of the tibia and tarsus or a fringing of all or a part of these segments on one or both margins with setae or in a combination of both, that is, a compression of the tibia and tarsus and a fringing with setae. The prolegs only rarely function for swimming. The mesolegs and metalegs are both frequently modified in certain groups while in others only one pair may be modified. The legs that are fitted for swimming must have the parts so articulated as to form a rigid oar-like appendage with a rolling articulation at the proximal end. A structural arrangement by which the tarsus could be feathered upon recovery is a great advantage. This results in dead specimens apparently having the tarsus upside down. Such an appendage would be straight, horizontal, and rigid. An appendage that is a highly efficient organ for locomotion in a fluid, is a very inefficient appendage for locomotion upon land, since in walking and running the legs must be bent at an angle at the tibia-

flexis. This is the reason why many large aquatic insects make a thumping noise while walking.

Hydrous Triangularis.—The mesolegs and metalegs are fitted for swimming. Study a metaleg. The coxa is large, transverse, and flat on the ventral aspect. The trochanter is articulated in the mesal end. The coxartis is a hooked projection at the opposite end. There is a sternartis located at the mesal end. The coxatrocliae fit socket-like about the trochanter. The femasuture is immovable. The femur is convex and compressed. The dorsal side of the proximal end is produced and articulates against a coxatroclia. The femafossa is distinct. The patella is a narrow transverse plate. The fematrocliae are continuous, forming a socket for the articulation of the tibia. The tibiaflexis is wanting. The tibia is subcylindrical. Its surface is pitted with a short conical setae inserted in each pit. The distal margin is fringed with short stiff setae. The calcaria, one longer than the other, are slender and spine-like. The tarsus can be inverted so that the dorsal side is turned ventrad. It consists of five segments. The first segment is short, the suture between the first and second segments is long and oblique, which permits of a rotation of the tarsus after the stroke. The ventral surface of each segment bears a row of short spine-like setae. The dorsal aspect of segments two to five bears a band of long swimming setae. Tulilli are wanting. The claws are long, stout, curved, and appendiculately toothed.

Draw the caudal aspect of a metaleg and name all the parts.

The tubercula is a minute quadrangular projection concealed in the distal end of the fifth tarsal segment. The orbicula is membranous. The calcanea is shield-shaped. The distal end is broad, deeply angularly emarginate, the sides forming minute pointed slightly hooked claws. The auxiliae are wanting. The planta is a slender onychium-like projection attached in the bottom of the emargination of the calcanea. The distal end of the planta bears two adjacent setae, as long as or longer than the claws.

Draw the dorsal aspect of the articularis and name all the parts.
Draw the ventral aspect of the articularis and name all the parts.

Dineutes Assimilis.—The prolegs are long, slender, oar-like, as long as the body; the mesolegs and metalegs are short paddle-like about as long as the width of the body. Study a proleg. The coxa is transverse oval, the trochanter articulated in the mesal end. The coxartis is situated at the lateral end. The coxatrocliae are small. The trochanter is normal in form. The femasuture is movable. The femur is subcylindrical, elongate. The fematrocliae are small. The patella is large. The tibiaflexis is prominent. The tibia is

gradually enlarged toward the distal end. The ventral margin bears a double row of closely placed setae. The cephalic surface bears a few large setae inserted in pits and the caudal surface at the distal end bears an elongate setiferous area. Calcaria are wanting. The tarsus consists of five segments. The dorsal margin of each segment bears a close band of short white swimming setae. The ventral surface of the first to fourth segments bears tufts of setae. The claws are long, slender, and abruptly bent near the proximal end. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.

Study a mesoleg. The coxa is oblique, transverse, and located in a coxacava. The coxatrocliae are prominent, surround the proximal end of the trochanter. The distal portion of the trochanter is a broad compressed free lobe. The femur is compressed, convex, and triangular in outline. The distal half of the dorsal margin bears a row of short white setae. The fematrocliae are small. The tibia is compressed, plate-like, the distal end broadest. The dorsal margin and the dorsal half of the distal margin bears long slender swimming setae. The ventral margin bears a band of short setae with two small divergent calcaria at its distal end. The tarsus consists of five compressed plate-like segments. The first segment is largest, triangular. The second and third segments are short, transverse. The fourth and fifth segments together form a more convex transverse area, the fifth segment smallest. The dorsal margin of the segments bears a band of long slender swimming setae and the ventral margin a band of short setae. The claws are long, slender, and abruptly hooked near the proximal end. Tulilli are wanting.

Draw the caudal aspect of a mesoleg and name all the parts.

Notonecta Undulata.—The prolegs are modified for grasping. The metalegs are fitted for swimming. The mesolegs are intermediate in structure between the prolegs and the metalegs. Study a metaleg. The coxa is oblique, inserted in a coxacava, with a long trochantin along the cephalic margin of the proximal half. The coxartis is a small condylar knob. The coxatrocliae are small. The trochanter is elongate, articulated to the coxatrocliae. The femasuture is movable. The femur is cylindrical and articulated to the dorsal side of the trochanter. The fematrocliae are small. The femasulcus is distinct and each margin bears a row of short stout conical setae among which are a few long fine setae. The patella and tibiaflexis are wanting. The tibia is subcylindrical. The middle of the ventral aspect bears a row of short conical setae. Each side of the ventral aspect bears a row of long adjacent flexible

swimming setae. The tarsus consists of two segments, the first much longer than the second. Both segments bear a row of long flexible swimming setae along each side of the ventral aspect, continuous with those of the tibia. The ventral aspect also bears a short median band of short conical setae. The tulilli are wanting. The claws are present, they resemble setae. They are usually said to be wanting. Their articulation to the articularis, the broad proximal portion and curved distal portion will serve to identify them.

Draw the ventral aspect of a metaleg and name all the parts.

Corisa Kennicottii.—The legs are all very different. Study a proleg. The coxa is inserted in a coxacava. It is vertical, subcylindrical with a coxasulcus on the lateral aspect. The coxatrocliae are wanting. The trochanter is geniculate. The femur, held at right angles to the coxa, is subcylindrical. The fematrocliae are wanting. The tibia is very short, subcylindrical. The tibiaflexis is indistinct. Calcaria are wanting. The tarsus consists of a single three-sided segment. The cephalic and caudal margins of the ventral oval area bears a band of long slender setae. The claws are described as wanting. The long slender seta-like structure at the distal end of the tarsus, attached to the articularis, is the single claw. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.

Study a metaleg. The coxa is cup-shaped. There is a small trochantin attached to the cephalic margin. The coxartis is an acetabulum. The coxatrocliae are large and prominent. The trochanter is short, swollen. It is joined to the ventral surface of the femur. The latter is swollen, bears a band of setae on the ventral margin, is longer at the distal end. Patella and fematrocliae are wanting. The tibia is flattened, the dorsal and ventral margins are fringed with oblique rigid setae. There is attached cephalad of each of these bands a band of long flexible swimming setae. The caudal side of the tibia bears a lobe-like tibiatroclia. The tarsus consists of two compressed segments, the second very short. The dorsal and ventral margin of each segment is fringed with oblique rigid setae. There are bands of long flexible swimming setae cephalad of each of these bands. The articularis is inserted on the ventral margin some distance before the distal end. It bears a single seta-like claw. Tulilli are wanting.

Draw the caudal aspect of a metaleg and name all the parts.

Benacus Griseus.—The prolegs are fitted for grasping, the mesolegs and metalegs are fitted for swimming. Study a metaleg.

The coxa is enclosed in a coxacava. It is cylindrical, the dorsal side is greatly prolonged, bearing a coxartis at its distal end, and a trochantin along its cephalic margin. The coxatrocliae are large. There is a prominent transverse trochella in the trochacoria. The trochanter is elongate. Its long dorsal margin is joined to the femur with an immovable femasuture. The shoulder of the femur articulates against the coxatroclia. The femur is long, subcompressed, stout. The fematrocliae are distinct. The shallow femasulcus is margined on each side, more complete on the caudal, by a fringe of flexible swimming setae. The patella is a distinct narrow transverse plate. The tibiaflexis is wanting. The tibia is strongly compressed, triangular in outline. The tibiatrocliae are prominent, angular. The dorsal and ventral margins of the tibia bear a row of long flexible swimming setae. Each of these are supported on the caudal side by a dense row of short oblique supporting setae and a similar row on the cephalic side of the ventral row. The tarsus consists of three segments. The first segment is small and in great part concealed by the tibiatrocliae. The second and third segments are strongly compressed. The dorsal margin of the second and third segments bears rows of swimming setae and setae arranged like those of the tibia. The claws are long, pointed, curved on the distal portion. Tulilli are wanting.

Draw the caudal aspect of a metaleg and name all the parts.

4. SALTATORIAL LEGS

The saltatorial type of leg, the one fitted for jumping or springing, has certain of the segments either greatly enlarged or greatly dilated. This expansion of the segments makes room for the extra muscles that are needed in producing sudden and vigorous movements. The great majority of the insects with a saltatorial habit use the metathoracic legs. The femur is either greatly expanded or greatly elongated and the tibia, which is usually of good length, is distinctly bowed and with well developed calcaria at its proximal end. The tibiaflexis permits the tibia to be placed well under the femur, when the leg is at rest, in such a position as would make it most advantageous in jumping. The calcaria, which are located on the ventral side of the proximal end of the tibiae, serve to improve the fulcrum. The prolegs and mesolegs in this type are of the ordinary ambulatory type.

Melanoplus Differentialis.—The metalegs are greatly elongated. Study a metaleg. The coxa is cylindrical, obliquely united to the thorax, much longer on the lateral than on the mesal aspect. The coxartis is the black infolded area near the trochantin. The

coxatrocliae are wanting. The trochanter is small, best seen from the ventral aspect. The caudal portion bears a finger-like projection which articulates in the margin of the coxa. The femasuture is immovable. The femur is greatly elongated, club-shaped. The proximal end is emarginate, the emargination bounded by two rounded shoulders which articulate against the coxa. The fematrocliae are large. There is a shallow femasulcus extends between them to the proximal end. The bottom of the femasulcus is transversely striate like a radula. The carina forming the caudal boundary of the femafossa has a short white spine near the middle of its length. The tibia is cylindrical, subequal in length to the femur. The tibiaflexis is very prominent, bent at a right angle. The dorsal aspect bears a double row of conical black spines. The four long stout strongly hooked calcaria are located on the ventral side. The tarsus consists of three segments, the first and third segments subequal, the second much shorter. The first segment bears three arolia, the distal longitudinally grooved. The second segment bears a single emarginate arolium. The claws are short, stout, hooked, and obscurely dentate. The artarolium is very large.

Draw the caudal aspect of a metaleg and name all the parts.

Blepharida Rhois.—Study a metaleg. The coxa is transverse, and the trochanter is articulated to its mesal end. There is a sternartis at the mesal end and a coxartis at the lateral end. The coxa rolls on these articulations. The coxatrocliae although small are distinct. The cephalic surface of the trochanter is triangular. The femasuture is oblique. The femur is diamond-shaped, compressed, and greatly swollen. The fematrocliae are small, the femasulcus is distinct. The tibiaflexis is prominent, nearly a right angle. The distal portion of the tibia is enlarged, a low mound-like prominence on the middle of the dorsal side. There is a prominent tibiasulcus on the distal half of the dorsal aspect, closely fringed on each side with setae. The single calcar is short, stout, hooked, and ventral in position. The tarsus consists of five segments. The condylar swelling of the proximal end of the first segment resembles an extra segment. The third segment is broadly dilated and the fourth segment is articulated to its dorsal surface. The fourth segment is a minute cylinder fused to the large fifth segment. The claws are minute, cleft, and the outer ray is longer than the inner. The first to third segments have pulvines.

Draw the caudal aspect of a metaleg and name all the parts.

Leucospis Affinis.—Study a metaleg. The coxa is greatly swollen, subpyramidal. The surface is pitted, each pit bears a seta. The coxatrocliae are small, but distinct. The coxasulcus is marked,

its caudal margin modified into small tooth-like or mound-like projections. The trochanter is small. The proxatrochanter forms the greater part of the trochanter. The distatrochanter is limited to a small ring fused to the proximal end of the femur. The greatly swollen femur is subcompressed, about twice as long as wide. The ventral margin has a blunt tooth at middle and a row of several much smaller sharp-teeth, forming the cephalic boundary of a deep femasulcus. The fematrocliae are small. The tibia is so bowed that it fits against the ventral surface of the femur. The tibiaflexis is wanting. The distal end is bowed and bears two short divergent calcaria on the ventral aspect. The tarsus consists of five segments. The distal ends of the segments are oblique, the ventral surface is setiferous. There is a prominent arolanna on the articularis. The claws are minute, strongly hooked, and appendiculately enlarged.

Draw the caudal aspect of a metaleg and name all the parts.

5. RAPTORIAL LEGS

In insects with legs of the raptorial type, the modification for grasping and holding is limited to the prolegs, while the mesolegs and metalegs are fitted for walking. Where the legs are not decidedly modified, the prolegs may also be used for walking, but wherever the raptorial type is highly developed, the prolegs are of such form that the insect can not use them for walking. The typical form of a grasping leg has an elongate coxa, a geniculate trochanter, a long swollen or a short rotund femur, and a tibia with a strongly angular tibiaflexis so that the tibia and tarsus, if the latter is present, can be folded against the ventral surface of the femur like a knife-blade is folded into its handle. The ventral surface of the femur and tibia bears many or a few, small or large, spines or sharp setae, which are divaricate and aid in holding the victim. Where the raptorial type is highly developed, there is correlated with the modification of the structure of the legs, a great lengthening of the prothorax.

Benacus Griseus.—Study a proleg. The coxa is directed ventrad. One side, the lateral, is much longer and bears the coxartis and the trochantin on the cephalic side. The coxa is cylindrical. The coxatrocliae are large. The trochanter is geniculate. The femacoria is flexible. The trochella is a broad transverse area in the dorsal trochacoria. The femur is large and stout, enlarged on proximal portion, and expanded around the femacoria. The ventral surface is convex and velvety. The fematrocliae are very large and stout. The tibiaflexis is concealed by the fematrocliae. The patella is twice as long as wide. The tibia is bowed, cylindrical. The ven-

tral surface is convex and velvety. Calcaria are wanting. The tarsus consists of three segments, the first is in great part concealed in the emarginate end of the tibia. The ventral surface of the segments is convex and velvety. There is a single large pointed hooked claw. This is the cephalic claw. The rudiment of the caudal claw can be identified adjacent to the proximal end of the cephalic claw. Tulilli are wanting.

Draw the caudal aspect of a proleg and name all the parts.

Reduvius Personatus.—The prolegs and mesolegs are very similar in form. They are different from the metalegs. Their form would suggest that both were fitted for grasping. Study a proleg. The coxa is subcylindrical, the lateral portion prolonged and inserted in a coxacava. The coxatrocliae are small and the trochanter is geniculate, small, and the femasuture is oblique. The femur is subcylindrical, the entire surface is setiferous, particularly the ventral aspect. The fematrocliae are wanting. The patella is quadrangular and almost completely fills the gonycoria. The tibia is cylindrical, the surface densely setiferous. The distal portion of the ventral aspect bears a prominent swollen tibiarolium. Its surface bears numerous retineriae. Calcaria are wanting. The tarsus consists of three cylindrical segments, the first shortest and geniculate. The surface of the segments is setiferous. The coria at the distal end of each tarsal segment is slightly swollen, forming small aroloideae. The claws are small, not strongly curved. Arolellae are wanting.

Draw the caudal aspect of a proleg and name all the parts.

Phymata Wolffi.—The prolegs are modified for grasping. Study a proleg. The coxa is inserted in a coxacava. The proximal end is condylar and then constricted. The distal portion is elongate and swollen. The caudal coxatroclia is angular, the cephalic is wanting. The coxasulcus is shallow, the caudal side guarded by a row of small blunt projections. The proximal projections are the longest, others sometimes inconspicuous. The trochanter is geniculate, the distal portion largest, articulated in the cephalic side of the femur. The femasuture is immovable and the proximal shoulder of the femur articulates against the coxa. The femur is short and broad, bowed. The dorsal margin is straight with a row of small blunt projections, the ventral is convex. The middle of the ventral margin bears a blunt thumb-like tooth with a row of short stout holding spines between the tooth and the distal end. The patella is the small irregular sclerite in the gonycoria. The tibia is a hook-shaped or scimiter-shaped piece. The caudal side of the ventral margin bears a row of short stout holding spines on the caudal side of

the ventral margin. These impigne against the similar structures of the femur. Calcaria are wanting. The tarsus is minute and frequently broken from pinned specimens and consists of two cylindrical segments, the tarsacoria is located on the dorsal aspect of the tibia some distance from its distal end. The two claws are minute, slightly curved. Tulilli are wanting.

Draw the cephalic aspect of a proleg and name all the parts.

Stagmomantis Carolina.—Study a proleg. The coxa is greatly elongated, five or six times as long as wide. One side of the proximal end, the lateral, is prolonged and bears the coxartis. The trochantin is located just cephalad of the coxa. The coxatrocliae are rounded lobes. The median ridge of the dorsal margin bears a row of round slender blunt projections. The trochanter is long, not geniculate. The femasuture is immovable. The femur is elongate and the fematrocliae are large. The patella almost fills the gonycoria. The femasulcus extending from the fematrocliae is very prominent. The caudal side bears four or five equidistant short conical setae. The cephalic side has at the proximal end several short blunt tubercles, distad of which there are three large spine-like setae, the distal one longest. Between this latter group and the remainder of the short spine-like setae of the cephalic margin there is an oblique furrow in which the long pointed hooked distal end of the tibia fits. The tibia is cylindrical and the distal end is prolonged as a long stout pointed hooked projection. The tibiaflexis is right-angled. Each side of the ventral aspect bears a row of short stout decumbent spine-like setae. The tarsus consists of five cylindrical segments. The basitarsis is as long as all the other segments together. Segments one to three bear a small inconspicuous arolium at the distal end, the fourth segment bears a large emarginate arolium. The artarolium is wanting. The claws are small, not strongly curved and pointed.

Draw the cephalic aspect of a proleg and name all the parts.

CHAPTER VII

WINGS

The wings of insects are attached to the notacoria of the mesothorax and metathorax. They are operated by strong muscles located in these segments. Each wing contains a series of thickened lines, the veins, between which there are thinner membranous areas, the cells. The thickened proximal ends of the veins, the venellae, and the sclerites of the rotaxis, the pteraliae, articulate against the alariae and aliferae.

True organs of flight are present in birds, bats, and insects. The arms in birds and bats are modified into wings, but in insects the origin of the wings has not been determined. Four theories have been proposed to account for their origin. The wings, which begin their development either late in embryonic development or early in postembryonic development are functional only in the adult. It has been suggested that the wings are modified thoracic tracheal gills or have originated from the covering plates of tracheal gills. In existing insects it is the exception rather than the rule to find tracheal gills on the thorax and, when present, they are not attached in the region of the notacoria It is true that the covering plates are similar in shape and in the arrangement of their tracheae to a developing wing, but a similar arrangement of tracheae is found in other developing parts, as the octavalvae, appendages that could have nothing whatsoever to do with the origin of the wings. The progenitors of insects, as well as those forms in which the wings originated, were land animals without tracheal gills or covering plates. The aquatic habit was undoubtedly acquired after the development of wings, so that theories deriving wings from tracheal gills or their covering plates are untenable.

Certain fossil and existing insects have the lateral margins of the thoracic segments dilated as thin horizontal projections. It has been suggested that these projections were used by primitive insects in parachuting from elevated positions. It is believed that the expansions, which are present on all three thoracic segments, became enlarged by use, articulated to the thorax, and consequently movable, and limited to the mesothorax and metathorax. As to how such efficient organs as the wings of insects could be developed from the rigid, strongly chitinized, lateral projections of the notum

of modern insects and at the same time limited to the two caudal segments of the thorax, is difficult to imagine. This is, nevertheless, the most plausible theory that has been proposed.

The fourth theory, that the wings originated from disk-shaped cell masses derived from the mesospiracles and the metaspiracles, is vouched for by Verson and Tower. During embryological development the mesospiracles migrate onto the prothorax and the metaspiracles degenerate in certain Entopteraria, leaving behind in each case cells which are concentrically arranged and which develop into a disk-shaped mass. Tower believes for three reasons that this mass develops into a wing, first, because the disk of the wing arises in the same region; second, because the wing-disc frequently shows a concentric arrangement of cells; and third, because, if the wing is not derived from the remains of a spiracle, the spiracle must degenerate and new hypodermal cells be formed from which the wing is derived. Powell has shown that such an origin is impossible because in many insects there is no migration of the mesospiracles and the metaspiracles are present, at least as rudimentary structures, and no disk-shaped masses can be formed.

The four theories to explain the origin of wings are not so different as might at first appear. The tracheal gills, the covering plates of tracheal gills, the lateral extensions of the notum, and the spiracles are all similar structures, projections or modifications of the body-wall. The wings are not modified limb-rudiments because they do not arise until long after the appendages of the segments are formed and developed into legs. While there is a disagreement as to the origin of wings, most investigators are agreed that they have arisen only once. If the wings have arisen only once, it may be assumed that the thickened lines or veins also have arisen only once. This assumption is borne out by the homology found to exist between the veins of the wings of all insects.

Wing Shape.—The wings of insects are very different in shape. Where two wings are present on each side of the thorax, the usual condition, they are generally different in form or they are at least never identical. The difference in the shape of the wings is correlated with the type of flight of the insect. In addition to the variation in shape, there may be a variation in the texture of the two wings of the same side. The shape or contour of the wings, while very different, includes certain characteristics which are common to all. These have received special names. The relation of these parts can be best understood by the examination of a pair of wings. For this purpose the two wings of a Differential Locust will be used. The wings of the mesothorax are thick and leathery while those of

the metathorax are thin and membranous. The latter, when at rest, are folded or plaited like a fan and concealed under the mesothoracic wings, and when expanded, they are several times the size of the mesothoracic wings. The wings in the following pages are described as if held horizontal and perpendicular to the lateral aspect of the body, that is, in the normal position.

Veins.—The line-like thickenings extending from the proximal end of the wing to its periphery are the veins. Their arrangement and identification will be discussed later.

Cells.—The spaces included between the veins are the cells. They are usually named from the veins that surround them. If the cell is completely surrounded on all sides by veins, it is said to be closed, if not so surrounded, it is said to be open.

Angles.—The proximal portion of the cephalic margin of a wing is the humeral angle. It is usually not an angle until the wing has been removed from the thorax. The angle located at the most distal portion of the wing is the apical angle. It is usually broadly rounded. The angle located on the caudal margin between the apical angle and the proximal end of the wing is the anal angle. It varies considerable in position and is frequently broadly rounded. In the mesothoracic wing it is placed near the proximal end and in the metathoracic wing distant from it. The proximal portion of the wing or the portion that attaches it to the thorax is the base. The distal portion of the wing, the region bearing the apical angle, is the apex.

Margins.—The cephalic margin, which extends between the humeral and apical angles, is the costal margin. It is also known as the front or cephalic margin. The portion of the margin extending between the apical angle and the anal angle is the outer margin. The portion of the margin extending between the base and the anal angle is the anal margin. It is also known as the inner margin. The anal margin, particularly in the Diptera, frequently is divided into two parts by a deep line-like incision, the axillary incision.

Pteraliae.—The small plates and projections located in the proximal end of the wing and articulating against the alariae and aliferae are the pteraliae. Some of them can usually be identified in wings mounted on slides.

Draw a mesothoracic wing, fully expanded, and name all the parts.

Venation.—The texture of the wings was employed by the early systematists in separating the major groups, but the form and number of the veins and cells, the venation, was not used. With the increase in the knowledge of the anatomy of insects, not only the texture of the wings, but the modifications of the venation were

utilized. In order to be able to use the various parts, a nomenclature became necessary. Since different groups of men were studying different groups of insects, the result was the gradual evolution of a distinct nomenclature for each order. The various nomenclatures in most cases had no relation to each other, either as to the homology of the parts and frequently as to the names of the parts. The multiplication of nomenclatures proceeded so far in some orders that they varied not only with the author but even the same author used a different nomenclature for different families of the same order. Such a system of naming veins was a purely arbitrary one. Names were applied to the whole or parts of veins without any regard to the identity of the corresponding veins in closely allied families. No attempt whatsoever was made to homologize the veins. This was impossible, because an entire lack of the means necessary for comparison, a uniform system of nomenclature, was not available.

The terminology in use at the present time is of two kinds, first, an arbitrary system for each order and, second, a uniform system applicable to all orders. The arbitrary systems of modern taxonomists, while different in terminology for each order, has been modified and improved over the systems of the early workers, though they are still artificial and no attempt is made to homologize the veins, even in the same order. The point of view of those who adopt the arbitrary systems as regards the number of the wing-veins, is entirely different from those who use the uniform nomenclature. The former believe that the wing with the smallest number of veins should be considered as the primitive type. That is illustrated by the condition found in the order Diptera, where a wing containing almost the minimum number of veins, that of the house-fly, is adopted as the type. In those wings containing more veins than are present in such a selected type, the additional veins are regarded as later acquisitions. Such wings are considered as representing a more complex type and special names are applied to these additional veins. Those who use the uniform system consider those wings with a large number of veins as being nearer the primitive type, generalized, and the wings with a minimum number of veins as the complex or specialized type. The modification consists in the addition of veins by one view and in a reduction in the number of veins by the other.

Uniform Nomenclature.—The desirability of one system of names for the wing-veins of all insects was first suggested by Herman Hagen in 1870. G. Ernest Adolph published, 1879, the results of investigations from which he was led to believe that the veins

were of two kinds, first, concave veins or primary veins and, second, convex veins or secondary veins. The first serious attempt to homologize the wing-veins of all orders was by Josef Redtenbacher, 1886, and for this reason the uniform system of naming veins is known as the Redtenbacher System. He named the veins, costa, subcosta, radius, media, cubitus, and anal. They were labelled with Roman numerals to which in the case of the branched veins Arabic numerals as exponents were added. Redtenbacher adopted the convex and concave vein-system of Adolph. Two years later in conjunction with Friedrich Brauer, he showed, from a study of the ontogenetic development of a wing of a dragon-fly, that both convex and concave veins are preceded by tracheae. The homology of the veins of lepidopterous wings was determined in 1892 by Arnold Spuler from a study of their ontogenetic development. The first contribution to wing-venation by John Henry Comstock was published in 1893. This dealt with the wings of carboniferous insects and Lepidoptera, which were used to exemplify a method of phylogenetic study. The Redtenbacher system was further amplified in

Fig. 11.—Hypothetical type (after Comstock and Needham).

his "Manual for the study of insects," published in 1895. The publication of the results of a comprehensive series of studies of the ontogenetic development of veins dealing with the wings of all orders was begun in 1898 by John Henry Comstock and James George Needham. They adopted the names of Redtenbacher for the veins but used abbreviations of the names of the veins combined with Arabic numerals as indexes. They attempted to show that the wing of the primitive insect consisted of only a few veins. Upon this they based their figure of a hypothetical wing-type (Fig. 11) and their conclusion that the many-veined wings were derived from this type by the addition of veins. The details of the connection of the body and wing-tracheae was shown by Gunther Enderlein in 1902. That the many-veined wings of insects represented the primi-

tive condition, as was also held by Redtenbacher, was strongly argued, 1906, by Charles William Woodworth. The most comprehensive work dealing with wing-veins is that of Comstock, 1918, "The wings of insects," which contains over four hundred pages and figures and a complete bibliography. One of the most active writers of the present time is Robin John Tillyard who adopts the Redtenbacher System together with a modified form of the hypothetical type of Comstock. He differs as to the number of branches of the main veins and evidently holds a somewhat similar view to that of Woodworth, namely, that the wings of primitive insects were those with many veins.

Phylogeny.—The publication of the theory of Natural Selection had a marked effect upon the manner in which all animal structures were considered. The extension of the evolution hypothesis brought to light new terms. Naturalists began to talk about phylogeny, which is the history of the development of the race, and ontogeny, which is the history of the development of the individual. By a study of their morphology and development, the individual and the race were considered as to whether they showed a nearness or remoteness in their form and structure to some primitive or ancestral progenitor. Those showing a nearness to such an ancestor were said to be generalized and those showing a remoteness, originating much later in time, were said to be specialized. Systematists were early led to try to determine the evolution or phylogeny of groups of animals. The effect of evolution has been written more clearly on the wings of insects than on most other animal structures. A comparative study of the wings of insects, therefore, serves a double purpose. It teaches something as to the names and homologies of the veins but also shows the effects of evolution in changing the course of the veins and the shape of the wings.

It is essential in determining the phylogeny of any group, as pointed out by Comstock, to ascertain what are the most primitive members of such a group, to compare them, and to determine the ways in which they have been modified. In making these comparisons, the structure of a single set of organs should be studied intensively and the phylogeny of the group determined from such a study, then other sets of organs should be examined, until all the organs of the animal have been examined. Phylogenies based on these studies should be made, and then compared with the phylogeny first determined. If it is found that these successive phylogenies corroborate each other, we have a demonstration of the correctness of our conclusions. If they disagree, there is in-

dicated a need for a further examination of the disagreeing forms, for when correctly interpreted it will be found that the different records of the action of natural selection will not contradict but should confirm each other.

There arises, in working out the phylogeny of any group, the necessity for distinguishing between the different kinds of characters. These have been well stated by Comstock in his "Evolution and Taxonomy:"—

"First, characters indicating difference in *kind of specialization*, and second, characters indicating difference in *degree of specialization of the same kind*. The former will indicate dichotomous divisions of lines of descent, the latter merely indicate degree of divergence from a primitive type. Thus, it is shown that there are two distinct ways of uniting the two wings of each side in the Lepidoptera; they may be united by a frenulum, or they may be united by a jugum. These are differences in kind of specialization, and may indicate two distinct lines of descent or a dichotomous division of the order. Among those Lepidoptera in which the wings are united by a frenulum, great differences occur in the degree to which this organ, or a substitute for it, is developed; such differences may merely indicate the degree of divergence from a primitive type, and may need to be correlated with other characters to indicate dichotomous divisions."

There is also a necessity, as is further shown by Comstock, to distinguish between the characters used by systematists merely to make it possible for students to recognize the members of a group, *recognition characters*, and the *essential characters* of a group. The essential characters are not necessarily dependent on the presence or absence of any structure or on the form of any part of the body, but on the characteristic structure of the progenitor of the group and the direction in which the descendants of this progenitor have been specialized. Recognition characters are generally those first observed and used by the systematist. They may also be essential characters, but as a rule taxonomists search only for characters indicating a difference in kind. Specialization may take place in two very different ways—"first, by an addition or complication of parts, *specialization by addition*, second, by a reduction in the number or complexity of parts, *specialization by reduction*."

It should also be borne in mind, as pointed out by Meyrick, that when an organ disappears in any line of descent, it may not reappear in the descendants of this line, though a substitute might be developed for it. Even if such a substitute should be developed, it is not probable that the substitute would resemble the organ so

clcsely as to be mistaken for it. This emphasizes the value of the Darwinian aphorism, "that the presence of an organ, even if rudimentary, is of vastly more importance in determining the sequence of a group than its absence." Care must be used in applying Meyrick's law to make comparisons only between species in the same line of descent. One line may lose an organ much earlier than another. The organ may be lost very early in a line showing a generalized condition of other characters and be retained in another line which is highly specialized.

In determining the phylogeny of any group, those characters indicating a difference in degree of specialization of the same kind are most useful in allotting the rank of the group. Such characters are numerous in every large group as a whole, while others show only small lateral lines of descent or sidewise development. Characters indicating a sidewise development frequently arise independently several times, and do not indicate anything as to the line of descent of the group as a whole. This is illustrated by the secondary veins that are present on the radial sector in certain Diptera, Tipulidae and Asilidae, and develop into cross-veins in certain genera. A striking example is found in the grasping prothoracic legs of certain insects. Such legs are found in many orders and in practically every case their characteristic form is due to the elongation of the procoxae, but the presence of this type of leg does not imply any close relationship of all the insects bearing such legs. Caution must be used to differentiate between those characters that show the descent of the group as a whole and those characters that show only a sidewise development.

Wing Development.—The nymphs and larvae of insects with an incomplete and a complete metamorphosis always lack certain organs which are present in the adult. This is true of both of these groups so far as the development of the wings is concerned. The wings as well as the other lacking organs arise from special cell-islands, known as imaginal discs. Those of the wings, the wing-discs, usually originate in one of the early nymphal or larval stages. They may arise as late as the last larval stage or as early as the later stages of embryonic development. In insects with an incomplete metamorphosis the wing-discs appear to be prolongations of the caudo-lateral angles of the mesonotum and metanotum. They are in fact attached to the notacoria, are situated near the middle of each lateral aspect in the early nymphal stages of a grasshopper, arise as true lateral structures as shown by Tower, and are always exposed after the first molt. In insects with a complete metamorphosis the wing-discs are formed on the ental surface of the meso-

pleura and metapleura, usually in line with the rows of abdominal spiracles, and are always concealed in all stages of larvae.

The wing-discs are derived from certain cells of the hypodermis which become elongated and enlarged in the pleural region. Each develops as a disc-shaped area of polygonal cells. A longitudinal furrow or a circular pit is formed on the ectal surface of this disc-shaped area of polygonal cells by the invagination of its surface. If a circular pit is formed, it is soon transformed into a furrow extending the length of the disc-shaped area. The furrow or invagination deepens rapidly. The layer of hypodermal cells bounding this furrow is known as the propodal membrane, its dorsal surface as the dorsal propodal membrane and the ventral as the ventral propodal membrane, and the furrow or indentation which they bound as the propodal space. The cells of the dorsal propodal membrane become much thickened and are later evaginated, forming a projecting lobe. This lobe is the wing-fundament from which the wing is formed. The manner in which the wing-fundament is formed varies in the different orders of insects. Tower has described five types and states that there are numerous gradations between the first four. The following diagrams and descriptions

Fig. 12.—Simple type of wing-disc (after Tower).

are based upon those of this author. The figures represent longitudinal sections of the wing-disc and are arranged in each case with the earliest stage to the left.

Simple Type.—The wing-disc (Fig. 12) consists of slightly elongated cells which become invaginated and form a short propodal space. The ectal end of the dorsal propodal membrane is then strongly evaginated to form the wing-fundament, which grows in size and forms a prominent lobe, which includes the dorsal and ventral propodal membranes. The simple type, so far as known, is characteristic of all insects with an incomplete metamorphosis, as the Orthoptera, Odonata, Ephemerida, Hemiptera, and many families of Coleoptera, particularly the generalized ones. In the

latter order the wing-disc is always concealed during the larval stages by the external cuticle of the body.

Enclosed Type.—The wing-disc (Fig. 13) is horizontally invaginated. The cells of the dorsal propodal membrane becomes greatly thickened and later this membrane is evaginated to form the wing-fundament, which lies in a pocket formed by the ventral and the unevaginated part of the propodal membrane. The propodal space is very much restricted. The dorsal and ventral pro-

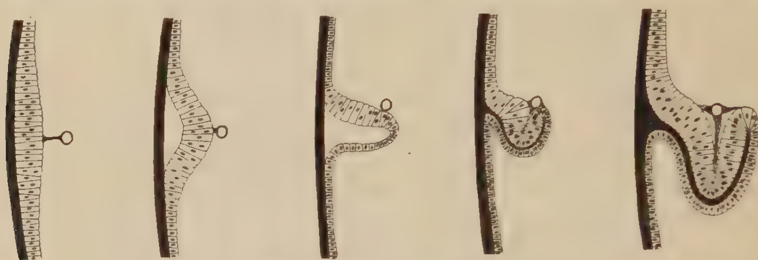

Fig. 13.—Enclosed type of wing-disc (after Tower).

podal membranes are pedunculate or stalked adjacent to the hypodermis. The enclosed type is characteristic of the families Coccinellidae and Chrysome[illegible] the Coleoptera and all the families of the Neuroptera [illegible]optera.

Recessed Type.—The wi[illegible] is broadly horizontally invaginated, forming a [illegible] space. Near where the dorsal and the ventral propodal membranes are continuous the

Fig. 14.—Recessed type of wing-disc (after Tower).

propodal membrane is evaginated, forming a wing-fundament, which lies in the propodal space with its end adjacent to the external cuticle. The recessed type is characteristic of the family Scarabaeidae of the Coleoptera and the nematocerous Diptera.

Stalked Type.—The wing-disc (Fig. 15) is narrowly horizontally invaginated, forming a small propodal space. The propodal membrane at the end of the imaginal disc is evaginated, form-

ing a wing-fundament, which lies in the propodal space. It is separated from the external cuticle by the long thin adjacent dorsal and ventral propodal membranes, so that the wing-fundament is located some distance within the body-cavity. The stalked type is characteristic of the cyclorrhaphous Diptera.

Detached Type.—The wing-disc (Fig. 16) is invaginated as in the stalked type and later, before the evagination of the wing-fundament, the dorsal and the ventral propodal membranes are cut off from the hypodermis and lie free in the body-cavity. It later

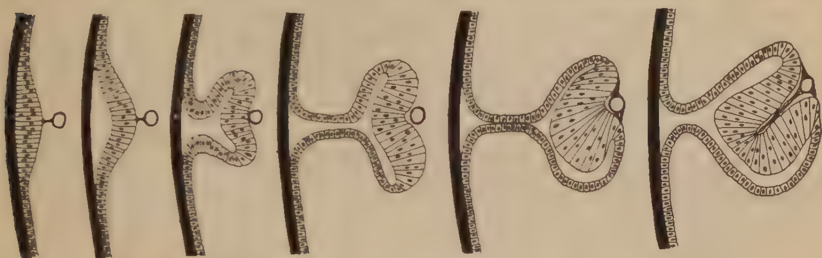

Fig. 15.—Stalked type of wing-disc (after Tower).

evaginates, forms a wing-fundament, and the free ends of the propodal membrane fuse with the hypodermis. The detached type, so far as is known, is found only in the dipterous genus Melophagus.

Wing-fundan[illegible] supplied with a [illegible]ndament of a nymph or larva is a flattened sack w[illegible] the cuticle [illegible]s open along the line of its evagination. The lumen or cavity [illegible] this sack is the future wing-cavity. A cross-section of a wing-fundament (Fig. 17, A) is a com-

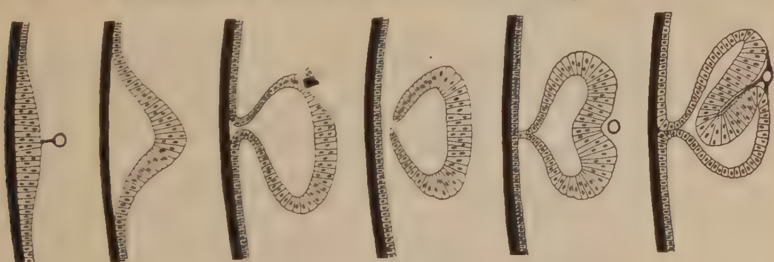

Fig. 16.—Detached type of wing-disc (after Tower).

pressed oval in outline so that there are two surfaces. These surfaces consist of a continuous layer of hypodermal cells which are bounded by a distinct basement membrane. The size of the wing-cavity is greatly reduced in the course of the development of the wing-fundament by the approximation of the basement membrane of the two surfaces. These surfaces come finally into contact for the greater part of their extent and later fuse. The cavities left where

the basement membranes are not fused, are the vein-cavities. Each is limited by a continuous layer of basement membrane and marks the position of the future veins of the adult wing. The hypodermal cells between the vein-cavities are greatly modified in shape and elongated, and form the wing-membrane. A surface view of a developing wing-fundament in its later stages (Fig. 22) shows broad whitish lines, the vein-cavities. These lines, which can be seen only in specially prepared specimens soon disappear. The vein-cavities are continuous with the body-cavity and are filled with blood. The band-like appearance of the vein-cavities is probably due not only to the contained blood but also to the shorter hypodermal cells which bound the vein-cavities. These cavities during the last nymphal stage and during the pupal stage become restricted in size and their walls strengthened by the deposition of chitin, so that in the adult the veins appear as strong convex lines on either side of the wing and the wing-membrane is modified into a thin flexible sheet of cuticle.

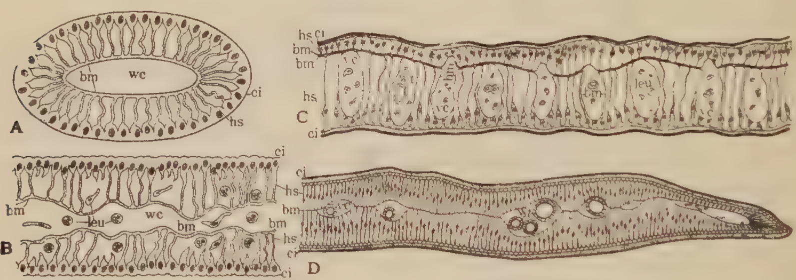

Fig. 17.—Sections of wing-fundament. A, hypothetical cross-section; B, longitudinal section before fusion of basement membranes (after Mayer); C, longitudinal section at time of fusion of basement membranes (after Mayer); D, longitudinal section after completion of fusion, showing vein-cavities (after Needham); *bm*, basement membrane; *ci*, cuticle; *hs*, hypodermis; *leu*, leucocyte; *vc*, vein-cavity; *wc*, wing-cavity; *wt*, wing-trachea.

There is shown in each of the figures illustrating the development of the different types of wing-fundaments (Figs. 12-16) a cross-section of a trachea in close association with the mouth of the wing-cavity. This is one of the large lateral longitudinal tracheae of the body from which the wing-tracheae are developed. The wing-tracheae arise in different ways, the simplest is where they arise as small branches and enter the wing-fundament when it is a small sack a millimeter or less in length, and become immediately functional. In their development they show a progressive series of modifications from the simplest condition, where they arise simply as branches of the longitudinal tracheae as in insects with an in-

complete metamorphosis, to the most complex condition found in insects with a complete metamorphosis.

The wing-tracheae in insects with an incomplete metamorphosis, the primary tracheae, enter the wing-fundament before the approximation and fusion of the layers of basement membrane and, therefore, before the formation of the vein-cavities. When the basement membranes fuse, there are cavities formed about the tracheae which are the beginnings of the vein-cavities, but the veins are not indicated as yet upon the external surface. The arrangement of the vein-cavities from which the veins are formed and, therefore, the venation, is the same. The tracheae increase in size with the growth of the wing-fundament, are never withdrawn from it, and persist in the wing of the adult. They are usually developed from two centers and arrange themselves in two distinct groups. This represents an early condition of the subdivision of the wing-tracheae and, therefore, of the vein-cavities, into two groups. With the expansion of the wing-fundament, there arises a necessity for a supply of air for the portions of the wing-fundament located between the vein-cavities, the wing-membrane. Certain of the cells of the wing-tracheae become swollen and from each such cell a small coiled tube, a tracheole, is developed, which later penetrates this region. These tracheoles, known as the secondary tracheoles, lack taenidea, but are supplied with a very thin intima. They do not become functional until the cuticular lining of the tracheae from which they are developed is shed or ruptured.

The wing-discs in most families of Coleoptera are developed in the same way as those of insects with an incomplete metamorphosis. They are of the simple type and differ only in that they are always concealed during the larval stages. There are small tracheal branches, the primary tracheae, which penetrate the wing-fundament from the lateral longitudinal tracheae. These small branches enter the wing-fundament before the fusion of the basement membrane and supply it with air until during the last larval stage, when a system of tracheoles, the temporary tracheoles, are developed from the lateral longitudinal tracheae of the body. The temporary tracheoles are functional for only a short time and disintegrate during the pupal stage. The wing-tracheae are also developed during the last larval and the pupal stage from the lateral longitudinal tracheae. They penetrate the wing-fundament after the formation of the vein-cavities and remain in the veins of the adult wing. Numerous tracheoles, the secondary tracheoles, arise from the wing-tracheae and penetrate the wing-membrane. Those Coleoptera in which the development of the wing-disc is of

the enclosed or recessed type differ only in that the primary tracheae may be represented by two single branches or two small groups of tracheal tubes. The primary tracheae and the secondary tracheoles of the Coleoptera are considered as homologous with the primary tracheae and the secondary tracheoles of insects with an incomplete metamorphosis, while the temporary tracheoles and the wing-tracheae are new structures.

The primary tracheae are wanting in the Lepidoptera. The temporary tracheoles are prominent and enter the wing-fundament after the basement membranes have begun to approximate but before their fusion. The vein-cavities, although their form and position has been determined, are not fully formed and are not indicated by external thickenings. The wing-tracheae enter the wing-fundament through the fully formed vein-cavities and become functional at the beginning of the pupal stage. The temporary tracheoles are pulled out or degenerate when the pupal stage is assumed. There are tracheoles, the secondary tracheoles, which develop from the wing-tracheae and penetrate the areas between the vein-cavities. The temporary tracheoles and the wing-tracheae are developed from two distinct centers and form two groups, a cephalic group of four tracheae and a caudal group of four. The latter give rise to eight tracheal trunks, which enter the vein-cavities and map out the venation. The vein-cavities are fully formed in the orders Trichoptera, Hymenoptera, and Diptera before the entrance of the wing-tracheae. These tracheae evidently follow the lines of least resistance and in most cases are not found in the veins to which they belong.

Wing-ontogeny.—The ontogenetic development of many animals shows structures that are lost in the adult. These structures were peculiar to the original progenitors or the early members of the race from which the individuals sprang. Thus, it is possible by such studies to trace certain of the changes that have taken place in the course of the development of the race and to determine the homology of the adult parts, of which the essential portions, present in the ontogeny, are wanting in the adult. An ontogenetic study of developing wings, comprising a determination of the number of branches and the arrangement of the eight wing-tracheae should shed much light on the homology of the veins. The arrangement of these tracheae in the wings of the generalized members of the different orders of insects should give some hints as to the plan of the venation of the wings of primitive insects. This is illustrated by the pupal wing of Sthenopis (Fig. 24, A), which is one of the most generalized lepidopterous wings known. In this wing the

wing-tracheae are represented as black lines and the vein-cavities as white bands. By an examination of the arrangement of the wing-tracheae and the vein-cavities in such a wing together with a comparison of these with the wing-veins of the adult, it should be possible to construct a hypothetical figure of a wing which would agree in most particulars with the wing of the progenitor of insects. While it might not be possible to determine the exact course of each vein, yet the number of primary veins and the number of branches of each could be decided. The hypothetical type of Comstock and Needham (Fig. 11), was devised in this way. If the figure of Sthenopis is compared with this hypothetical type, it will be seen that the two are almost identical. This type is a representation of a developing wing in which is shown the tracheae which precede the forming veins and is based upon the conditions found in a large series of nymphal and pupal wings. Many studies made since its publication have confirmed the conclusions of these authors and have shown its great value in determining the homology of veins.

That the vein-cavities are limited by the fusion of the two layers of basement membrane on either side of them has already been indicated. As development advances the size of the vein-cavities become more and more restricted by the continuation of this fusion and the aggregation about them of hypodermal cells, which deposit dense layers of chitin. In insects with an incomplete metamorphosis, where the approximation and fusion of the basement membranes are preceded by the entrance of the wing-tracheae, the completion of the vein-cavities does not take place until after the final molt. While in this group of insects all the veins are preceded by tracheae in the generalized forms, this is not true in certain specialized forms, particularly of the veins near the cephalic and caudal margins of the wing. The tracheae of these veins are frequently small and may be rudimentary or wanting. The elimination of these tracheae may have resulted from their disadvantageous position in relation to air supply or from a reduction in the size of the vein-cavities, making it difficult for the tracheae to find entrance.

The tendency of specialization in most organisms is toward the elimination of steps or stages in development and the advancing of the developmental steps that occur after the eliminated stages to a point earlier in the ontogeny. If the line of specialization in those wings in which at least most of the vein-cavities are entered by tracheae very early in their existence, has been the suppression of the tracheae in the veins adjacent to the wing-margin and the formation of these vein-cavities without tracheae, one should not

be surprised to find that this condition had been carried farther and that it is characteristic of all the vein-cavities of some insects. The first tracheae to enter the wing-fundament in the generalized Coleoptera are the primary tracheae, which are represented by two tracheal branches or several very fine branches in specialized Coleoptera and are wanting in the Lepidoptera and Trichoptera. When the wing-fundament reaches some size, it is aereated in the Coleoptera and Lepidoptera by means of the temporary tracheoles, which enter after the basement membranes have begun to approximate and before the closing of the vein-cavities. The wing-tracheae in insects with a complete metamorphosis, so far as known, are developed during the last larval stage and do not enter the wing-fundament until after the vein-cavities are fully formed. These tracheae do not become functional until during the pupal stage.

While the wing-tracheae in the orders Coleoptera, Neuroptera, and Lepidoptera have nothing to do with the determination of the position and arrangement of the vein-cavities, they are of great value in determining the homology of the veins. They are represented by the primary tracheal trunks and each always enters its homologous vein-cavity, that is, the radial tracheal trunk is in the radial vein-cavity, the medial tracheal trunk is in the medial vein-cavity, and so on. This makes it possible, where parts of veins are fused or atrophied, to determine what has taken place, because there is not a corresponding fusion or atrophy of the parts of the tracheal trunks. In the wings of certain specialized Lepidoptera, as the butterflies and some others, a modification of this condition is found that approximates and suggests the condition found in those orders where the tracheae enter after the formation of the veins. This is illustrated by the presence of tracheal branches in the cross-veins. In the orders Trichoptera, Hymenoptera, and Diptera another step in the ontogeny has apparently been lost. The vein-cavities and the wing-veins have been so altered in their course that the wing-tracheae, when they enter the wing-fundament, follow the lines of least resistance and are not in their homologous veins. The radial tracheal trunk may be in the medial vein-cavity or the cubital tracheal trunk may be partly in the radial and partly in the medial vein-cavity. It is self evident that any conclusions drawn from the arrangement of the wing-tracheae in such wing-fundaments are worthless. These orders so far as their other structures are concerned, are considered by all systematists as among the most specialized of insects. This specialization of wing-development is, therefore, in line with the specialization of their other structures. While the wing-tracheae have nothing to do with determining the

form of the venation in insects with a complete metamorphosis, it is obvious that they are a controlling factor in insects with an incomplete metamorphosis.

A comparison of the developmental conditions existing in individuals of the two sexes of the same species, shows that the structures of the female, if any difference exists, are as a rule, more generalized than those of the male. This is illustrated by the condition of the frenulum, which normally consists of several setae in the female and of a single large projection, bristle-like, in the male. This projection is formed by a fusion of setae, such as are found in the female. Only rarely does the male have a frenulum consisting of several setae, while in highly specialized females the frenulum is a projection formed by a fusion of setae. In tracing the development of the structures of the wing as well as of other parts of the body, this fact is often of the greatest value in determining the trend of modifications.

Longitudinal Veins.—The longitudinal veins are those that typically extend proximo-distad or lengthwise (Fig. 18) of the wing. They always have such a course in generalized insects, but in certain specialized insects portions of some of the longitudinal veins extend cephalo-caudad or across the wing. The proximal end of all the longitudinal veins is a single thickened ridge. Some of these veins extend to the wing margin as a simple vein and such veins are known as unbranched veins. Other veins subdivide into two or more branches before reaching the wing-margin and such veins are known as branched veins. The proximal portion of a branched or unbranched vein is known as the stem of the vein and each of the distal branched portions as a branch. The longitudinal veins are usually preceded by tracheae, but in those insects where the tracheae enter the vein-cavities after they are fully formed, the homology of the veins must be determined solely from an examination of adult wings and by comparing them with the hypothetical type.

The longitudinal veins are eight in number. They are designated, beginning with the cephalic or costal margin of the wing, as costa, subcosta, radius, media, cubitus, first anal, second anal, and third anal. The veins are frequently designated in descriptions and on figures by abbreviations of these names, thus, C, Sc, R, M, Cu, 1st A, 2nd A, 3rd A. The branches of the branched veins are designated by appending Arabic numerals as indexes or exponents to the abbreviations of the name of the vein, thus, R_2, R_3, M_3, Cu_2, etc. The cephalic branch of each branched vein is always numbered one. The unbranched veins receive the same designation through-

out their entire course. The proximal undivided portion of the branched veins is designated by the abbreviation for the vein, as, R, M, or Cu. This serves to discriminate, in the case of the branched veins, between the stem and branched part of the vein and also between the different branches of the same vein. The eight longitudinal veins are located as follows:—

Costa.—The unbranched vein extending along the cephalic or costal margin of the wing (Fig. 18) is the costa. It is designated by the abbreviation C and sometimes appears to be wanting, but is always considered as present and coinciding with the costal margin of the wing. Costa does not extend distad of the point where subcosta-one reaches the margin of the wing. The greater part of the ambient vein, which completely surrounds the margin of the wing is, therefore, secondary in origin.

Subcosta.—The forked vein located immediately caudad of and parallel to the costa (Fig. 18) is the subcosta. The stem is designated as Sc and the branches as Sc_1 and Sc_2.

Fig. 18.—Hypothetical wing-type.

Radius.—The radius is the vein (Fig. 18) located caudad of and parallel to the subcosta. It consists of a strong unbranched stem, which divides dichotomously. The cephalic branch of this division extends as a simple vein to the wing-margin. The caudal branch divides dichotomously, and each of these branches in turn divides dichotomously, making four branches which reach the wing-margin from the caudal half of the first dichotomy. The stem of the radius is designated as R and the branches as R_1, R_2, R_3, R_4, and R_5.

Radial Sector.—The radius at its first dichotomy divides into a cephalic unbranched portion, vein R_1, and a caudal four-branched portion. This caudal four-branched vein (Fig. 18) including all

its branches, is known as the radial sector and designated as R_s.

Radial Stalk.—The term radial sector is used in two very different ways, first, for the caudal four-branched portion of radius, including all of its branches, and, second, for the proximal unbranched portion. Some authors label the unbranched portion as R_s and define the radial sector to include all its parts, the branched and unbranched portions. Systematists frequently consider the proximal fused portions of veins as their stalks, consequently, the proximal fused portion of the radial sector (Fig. 21, A) may be known as the radial stalk. It is designated as R_t.

Media.—The media is the vein (Fig. 18) located caudad of and parallel to the radius. It consists of a stem which divides dichotomously into two branches and each of these branches in turn divides dichotomously, making four branches. The stem of the media is designated as M and the branches as M_1, M_2, M_3, and M_4.

Cubitus.—The cubitus is the branched vein (Fig. 18) located caudad of and parallel to the media. The stem is designated as Cu and its branches as Cu_1 and Cu_2.

First Anal.—The unbranched vein located caudad of and parallel to the cubitus (Fig. 18) is the first anal vein. It is designated as 1st A.

Second Anal.—The second anal vein (Fig. 18) is an unbranched vein. It is located caudad of and parallel to the first anal vein and is designated as 2nd A.

Third Anal.—The third anal vein is the branched vein (Fig. 18) located caudad of and parallel to the second anal vein. The stem is designated as 3rd A and the branches as 3rd A_1, and 3rd A_2.

Vein-continuity.—The anal veins are designated as 1st A, 2nd A, and 3rd A because they are independent veins. They should never be designated as A_1, A_2, and A_3, since this implies that they are three branches of a single vein, A. The adoption of such a nomenclature by certain writers is to be deplored. The three anal veins in the wings of some insects are fused into a single vein throughout their entire extent. Where this condition exists, for the sake of brevity, this single fused vein is designated as A instead of 1st A + 2nd A + 3rd A.

The branches of the branched veins are considered as extending from the proximal end of the wing to the distal margin. If radius and its five branches (Fig. 19, A) are taken as an example, the stem, designated as R, would be considered as a combination of all the branches of radius or $R_{1+2+3+4+5}$, which divides into R and R_s. In like manner the stalk of the radial sector, R_t, would be con-

sidered as a combination of all the branches of the radial sector or as $R_{2+3+4+5}$ which divides into R_{2+3} and R_{4+5}, and these in turn into R_2 and R_3, R_4 and R_5. In tracing the entire course of any one of the branches of radius by drawing a pencil over it, as R_4, beginning at the proximal end of the wing, it would first pass over the stem of R, then over the stalk of the radial sector, than over R_{4+5}, and finally over the free part of R_4. This implies a condition much more generalized than is found in the hypothetical type and for which there is but little basis. It has, however, been observed in the ontogenetic development of the veins of certain insects, that the tracheae of the branched veins (Fig. 19, B) do not unite to form the stem of the trachea in the usual manner, but extend free and ad-

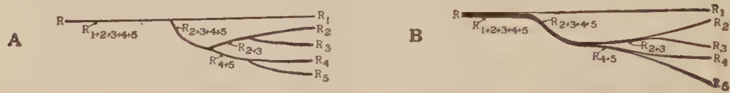

Fig. 19.—Continuity of the branches of veins.

jacent to each other from the distal to the proximal end of the wing. The stem of radius, instead of being represented by a single branching trachea consists of five adjacent tracheae. This interpretation, however, is implied by all of the users of the Redtenbacher system, as will be shown later in naming the cells, but is not stated by any writer.

The indexes for the stems of the veins are ordinarily placed upon the veins, while the indexes for the tips of the veins are placed opposite the distal ends of the veins around the periphery of the wing. These latter indexes should not be interpreted as the name

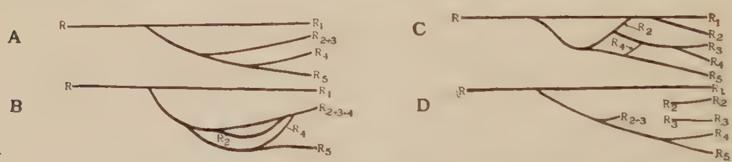

Fig. 20.—Coalescence and atrophy of veins. A, distal coalescence; B, proximal coalescence; C, anastomosis; D, atrophy.

of the entire vein opposite which they are placed but only of the portion of the vein at the margin. In the case of unbranched veins not combined with other veins, the label at the margin is the name of the entire vein. The course of R_4 just described illustrates well this point, a small portion at the margin is R_4 and is so labelled, but this vein passes through three other regions, each differently labelled as pointed out.

Coalescence.—A reduction in the number of longitudinal veins

or of the branches of the branched veins may take place by the fusion or coalescence of adjacent veins or by the atrophy of the whole or a part of a vein. The fusion of veins may extend from the proximal end of the wing (Fig. 20, A) towards the distal margin, a distal coalescence; from the distal margin (Fig. 20, B) toward the proximal end, a proximal coalescence; or by the approximation of two adjacent veins (Fig. 20, C) at some point more or less remote from the wing-margin and later their fusion for a greater or less distance, an anastomosis. The most common method of reduction is by a distal coalescence. It includes the fusion of the adjacent stems of veins at the proximal end and of the adjacent branches of the branched veins. A proximal coalescence arises from the approximation and fusion at the wing-margin of adjacent branches of the same or different veins. The stems of branches of the same or different veins may be modified by anastomosis. The process of fading out or complete disappearance of a whole or part of a vein is known as atrophy. It is a common method (Fig. 20, D) of reduction and may include either the stems of veins or their branches.

When two or more branches of any of the principal veins coalesce, this fact is indicated in the labelling of the vein by placing a plus sign (+) between the abbreviations of the names of the veins that have combined. If, for example, R_2 and R_3 combine, the legend would be R_{2+3} or if R_5 and M_1 combine, the legend would be R_5+M_1; while if any of the principal veins combine, as R, M, and Cu, the legend would be R+M+Cu. This implies that the branches of the same vein or of different veins, as well as the stems of different veins may fuse.

All that portion of a vein that does not coalesce with another vein is regarded as the free part of that vein. If media be taken as an example, then all that portion of M_1 between the point where it separates from M_2 and the margin of the wing would be the free part of M_1. It is also convenient to speak of the origin of the free part of a vein. This is the point or place where they separate or fork and does not refer to the actual point of origin of the vein at the base of the wing. If media be taken as an example, the point where M_1 separates from M_2 would be considered as the origin of the free part of M_1.

The study of a long series of wings shows that the tracheae of the branched veins always combine in a definite manner. This has to do only with distal coalescence and, therefore, only with the fusion of the branches of the branched veins. The radius may be taken as an example. This vein in the hypothetical type consists of five branches (Fig. 21, A). The stem divides dichtomously into

R_1 and the radial sector, the radial sector divides dichotomously into R_{2+3} and R_{4+5}, and these veins in turn divide dichotomously into R_2 and R_3, R_4 and R_5. Five other types may be developed from this five-branched type by the order in which the branches fuse. The second and third types are identical in that each contains four branches, but are entirely different in form. In the second type R_2 and R_3 are separate and the branches R_4 and R_5 are fused, forming the vein R_{4+5} (Fig. 21, B), while in the third type (Fig. 20, C), the branches R_4 and R_5 are separate and R_2 and R_3 are fused, forming the vein R_{2+3}. The fourth type or the three-branched radius (Fig. 20, D) may be formed from either the second or third type. It is derived from the fusion of either R_4 and R_5 of the second type or R_2 and R_3 of the third type, and consists of the branches R_1, R_{2+3}, and R_{4+5}. The fifth type (Fig. 20, E) or two-branched radius is the result of the fusion of the two branches of the radial sector of the fourth type, in which the four branches of the radial sector are fused into a single vein. The sixth type or

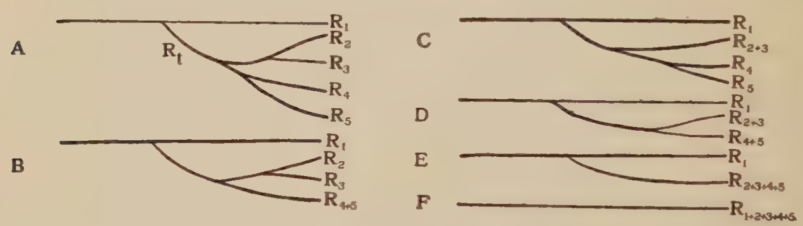

Fig. 21.—Sequence of coalescence in radius.

unbranched radius results from the fusion of the two branches of the fifth type (Fig. 20, F), R_1 and $R_{2+3+4+5}$, into a single vein. The reason why these veins fuse in the manner just described and why they do not fuse in a different order, as for instance, R_1 and R_2 or R_3 and R_4, is due to the amount of their coalescence. If the hypothetical wing-type (Fig. 18) is examined, it will be noted that R_1 and the radial sector are stalked, likewise R_2 and R_3, and R_4 and R_5. The distal coalescence of each of the branches of radius in its most generalized condition has proceeded so far that each branch has passed the point where it can form a distal coalescence with any other vein than the one named. Before the veins R_3 and R_4 could form a distal coalescence, a condition would have to be assumed where R_3 was not stalked with R_2 and R_4 was not stalked with R_5. This would mean that all these veins arose at the same point from R_1 or a common stalk. Such a coalescence implies a more generalized condition than is found in the hypothetical type. This type

is the simplest condition found in the wing of any insect. There is absolutely no reason why R_1 should not fuse with the proximal end of the radial sector, $R_{2+3+4+5}$, then with R_{2+3}, and finally with R_2. The only point is that an examination of a long series of wings by different students has proven that so far as observation goes the fusion always takes place in the way and in the order indicated. The other branched veins always follow a similar order in the reduction of the number of their branches.

Where wings are modified through atrophy, conditions arise that can not be expressed by the use of a plus sign. The transverse parts of the veins may drop out so that the vein extending to the wing-margin may consist of two or more distinct elements placed end to end. If for instance there was a vein consisting of three distinct parts, it would be clearly incorrect to label such a vein as $M_{3+4}+m+M_2$. Such conditions are more accurately expressed by the use of & and such a vein would be labelled, as, M_{3+4} & m & M_2.

Suppression Dichotomy.—While the conditions just described are true for all wings, they are apparently abrogated in others. This is due as a rule to another cause as in the front wings of most Lepidoptera where R_3 and R_4 are frequently coalesced, but such a fusion always follows and never precedes the type of branching found in radius of the hypothetical type. In these wings there was first a complete suppression of the dichotomy characteristic of the radius of the hypothetical type. This is due to two different causes. In one case there is an anastomosing of R_{2+3} and R_{4+5} with a later elimination of the cell enclosed between them and the suppression of the dichotomy, while in the other case the suppression is due to the atrophy of the free part of R_{4+5} as in the butterflies and many others. In some dipterous wings, as certain Tipulidae, there is a continuation of the distal fusion until the free part of R_{2+3} arises from R_4, suppressing the dichotomy. There is a suppression of the dichotomy of the radius in hymenopterous wings by an anastomosis similar to that found in the Lepidoptera.

Wing-areas.—The hypothetical type of Comstock and Needham (Fig. 11) shows the tracheae divided into two distinct groups, forming two wing-areas. The cephalic area comprises the tracheae representing costa, subcosta, radius, and media. This area is known as the costo-radial area and the tracheae or veins as the costo-radial group. The caudal area comprises the cubitus, first anal, second anal, and third anal. This area is known as the cubito-anal area and the tracheae and veins as the cubito-anal group. The costo-radial and the cubito-anal groups are distinct in the nymphal wings of Nemoura (Fig. 22) and the pupal wings of Sthenopis (Fig.

24, A). The tracheae that supply the costo-radial group all arise from the same trunk, which originates from the dorsal of the lateral longitudinal trachea. Those that supply the cubito-anal group also originate from the same trunk, which arises from the ventral of the lateral longitudinal trachea. The costo-radial and cubito-anal groups are distinct and unconnected in Nemoura. In many insects, however, the proximal tracheae of these groups are connected by a transverse trachea. This is indicated on the figure of the hypothetical type by dotted lines. The transverse trachea is frequently of such size as to be indistinguishable from the proximal tracheae, together with which it forms a single continuous large tracheal trunk. When such a single transverse trachea is formed, the medial trachea loses its close connection with the radial trachea and migrates along the transverse trachea (Fig. 11) until it is united with the cubito-anal group. The main trunks and transverse tracheae just described are located in the body-cavity and not in the wing-fundament.

Fig. 22.—Nymphal mesowing of Nemoura (after Comstock and Needham).

Theoretically each of the principal veins may be considered as something distinct and for this reason it is often convenient to refer to the different vein-systems, as the radial system, the cubital system, or the subcostal system; or two adjacent systems may be referred to as the subcosto-radial system or the radio-medial system. The wing is frequently divided into two regions with reference to the cubitus and anal veins. The region cephalad of the first anal vein is known as the preanal region and the remainder of the wing, including the first anal vein, as the anal region.

Cross-veins.—The short veins that connect the stems and branches of the longitudinal veins are the cross-veins. They receive their name of cross-vein from the fact that they usually extend across the wing, that is cephalo-caudad; they may extend, however, lengthwise of the wing, proximo-distad, parallel to the longitudinal

veins. Portions of the longitudinal veins also may extend cephalo-caudad so that the name of a vein can not be determined in all cases from the direction in which it extends. The cross-veins here described are such as are found in dipterous, lepidopterous, and hymenopterous wings and are known as the primary cross-veins. They are constant in location and are always situated between the same veins and never vary in this respect, but they do vary, however, in their exact position between these veins. While they are ordinarily located nearly midway between the proximal and distal ends of their respective veins, they may be located near the proximal or the distal end of the wing. The cross-veins are never preceded by tracheae in generalized insects as is shown by Nemoura (Fig. 22), so that it is possible in such wing-fundaments containing both tracheae and vein-cavities to differentiate the developing cross-veins from the developing longitudinal veins. In certain of the specialized Lepidoptera some of the primary cross-veins are strongly oblique and they are penetrated by tracheal branches that arise from the wing-tracheae. Their direction and the presence of the tracheae has led some observers to mistake them for longitudinal veins. Those wings where the number of wing-veins has been greatly increased, have developed in most cases a large number of extra cross-veins, the accessory cross-veins. These cross-veins are usually preceded by tracheae which are developed from the secondary tracheoles. It is impossible to identify the primary cross-veins, if such cross-veins exist, in wings provided with accessory cross-veins. The primary cross-veins are so constant in position, that they are evidently homologous, and are designated by names. The accessory cross-veins are never named. The following primary cross-veins can be identified:—

Humeral.—The humeral cross-vein is situated between costa and subcosta, near the proximal end of the wing. It is constant in position and presence, at least in generalized insects, and is designated as *h*.

Radial.—The cross-vein situated between R_1 and R_2 is the radial cross-vein. It is of quite general occurrence in the Hymenoptera and a few families of Diptera, and is designated as *r*.

Radio-medial.—The cross-vein situated between radius and media is the radio-medial cross-vein. It is usually located about midway between the proximal and distal ends of the veins, that is, near the point of separation of R_4 and R_5. This is one of the most persistent of the primary cross-veins and is designated as *r-m*.

Medial.—The cross-vein situated between M_2 and M_3 is the

medial cross-vein. Like the radial cross-vein it is quite persistent and is designated as *m*.

Medio-cubital.—The cross-vein situated between media and cubitus is the medio-cubital cross-vein. It is usually located about midway between the proximal and distal ends of the veins, that is, near the point of separation of M_3 and M_4 and is designated as *m-cu*.

Arculus.—The arculus is the cross-vein-like structure located near the proximal end of the wing between radius and cubitus. It is distinct in Sthenopis (Fig. 24, B) and is typically composed of two distinct elements. The cephalic half is a part of the stem of media and the caudal half is a cross-vein. The media (Fig. 23,

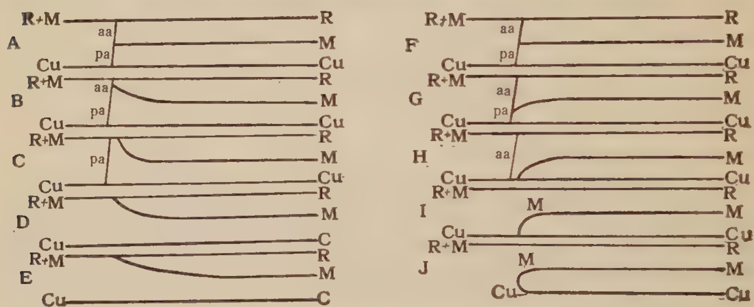

Fig. 23.—Modifications of the arculus.

A, F) in generalized insects extends parallel to radius in the proximal part of its course and, when near the proximal end of the wing, bends at a right angle, extends cephalad to the radius, and coalesces with it. The two veins, radius and media, extend as a single fused vein to the proximal end of the wing. The cross-vein extends between the angular part of the media and the cubitus. The transverse part of media together with the cross-vein is known as the arculus and is designated as *ar*. The parts of the arculus vary in form and size with the specialization of the venation. The proximal end of the media may migrate either toward the radius (Fig. 23, A-E) or the cubitus. If the media migrates toward the cubitus and combines with it, the arculus is wholly a part of the media in structure (Fig. 23, F-J). In order to differentiate the parts of the arculus the portion formed from the transverse part of the stem of media is known as the anterior arculus and is designated as *aa*. The portion of the arculus formed from a cross-vein is the posterior arculus and is designated as *pa*.

Spurious Cross-veins.—The cross-veins named and described above include all of the primary cross-veins that exist in any wing.

In some wings the longitudinal veins at certain points become angularly bent and on these angles there are developed spurs or veins that end blindly. These spurs are designated as *sp*. The spurs are sometimes continued until they fuse with an adjacent longitudinal vein and form a complete cross-vein. Such cross-veins are of rare occurrence, seem to be peculiar to certain families of insects, are known as spurious cross-veins, and are designated as *sp cv*. The spurious cross-veins have no relation to the primary or to the accessory cross-veins. Secondary cross-veins sometimes are present between two veins without reference to angular projections. Such cross-veins are of frequent occurrence in the Tipulidae. Where these cross-veins are constant in position they have been called supernumerary cross-veins and where inconstant adventitious cross-veins.

Draw the hypothetical wing-type (Fig. 18), add the primary cross-veins from the above description, name the longitudinal veins and the cross-veins.

CELLS.—The thin spaces between the veins, as already pointed out, are known as cells. The cells are named by applying to them the abbreviation of the name of the vein forming their cephalic boundary. The hypothetical wing-type shows the generalized arrangement of the longitudinal veins and cross-veins, so that this type should also show the generalized arrangement of the cells. If radius be taken as an example, the cell caudad of the stem of R is R, the cell caudad of R_1 is R_1, the cell caudad of R_2 is R_2, and so on.

The cells have been considered for the sake of convenience as consisting of two groups, first, the cells at the proximal end of the wing located between the stems of the veins and, second, the cells located at the distal end of the wing between the branches of the veins. The former are designated by the abbreviations of the stems of the veins and the latter by the abbreviations of the names of the branches of the veins. Such a grouping is sharply indicated in the case of radius and media by the radio-medial and the medio-cubital cross-veins. Since this is not true of the other branched veins and there is no subdivision of the cells caudad of subcosta and cubitus, the entire cell caudad of subcosta is designated as Sc and the cell caudad of cubitus as Cu.

When two veins fuse, the cell located between them is squeezed out and obliterated. In the hypothetical wing-type, the cell between R_2 and R_3 is R_2 and the cell behind the vein R_3 is R_3. When the veins R_2 and R_3 fuse, the cell R_2 is squeezed out and the cell behind the fused vein R_{2-3} is R_3. This will become clearer, if a series of diagrams are made showing successive stages in the

coalescence of R_2 and R_3. If the amount of coalescence of R_2 and R_3 is one-half more in each successive diagram over what it was in the preceeding one, the unfused part of R_2 and R_3 will eventually become infinitely small. The cell located between these veins also becomes infinitely small, but would still retain its designation of R_2 no matter how infinitely small it became, while the cell caudad of the vein R_3 would always be designated as R_3.

When the whole or a part of a vein atrophies, the cells that the vein separates are combined. Thus, if the free part of the vein R_4 were atrophied, there would be nothing to separate the cells R_3 and R_4 and this cell would be labelled not as R_3 or as R_4 but as R_{3+4}. The presence of a plus in the designation of a vein indicates a fusion of veins, but the presence of a plus in the designation of a cell indicates the atrophy or loss of a vein.

The three anal veins in certain insects fuse into a single vein and this vein in such cases is designated as A. The cell behind this vein is 3rd A. If the two caudal anal veins, 2nd A and 3rd A, atrophy so that all three anal cells are combined, the resulting cell is designated as A.

The cells of the wing may be divided by primary or spurious cross-veins. Thus, the costal cell is divided into two parts by the humeral cross-vein. When this occurs, the parts of the cell are numbered consecutively, beginning with the proximal one. The proximal part of the cell C would be 1st C and the distal part 2nd C. In certain families of insects, as some Diptera, spurious cross-veins are at times developed from spurs on the veins, the resultant subdivisions are labelled in the same manner as if subdivided by primary cross-veins. It has already been pointed out that two veins may approximate each other and anastomose distant from the margin or proximal end of the wing. When such an anastomosis takes place, a cell is divided into two parts. The two parts of such a cell are also designated in the manner just described. The cells between the accessory cross-veins are not named.

Name the cells in the drawing of the hypothetical wing-type.

WING-FURROWS.—The wings of insects are corrugated or folded along certain lines. In many orders these furrows are so persistent that they have been mistaken in some cases for veins. Although they are not so constant in position as the veins, yet they occupy so nearly the same relative position in a series of genera or families that it is generally possible to homologize them. The function of the furrows is twofold, to strengthen the wing and to make it more flexible. The furrows are neither homologous or analogous to veins. The following furrows may be present:—

Subcostal.—The depression near the cephalic margin in which the subcosta is located is the subcostal furrow. It is usually a concave depression with the subcostal vein at the bottom of the depression and is one of the most persistent of the furrows. Mounted wings of Diptera show the subcosta adjacent to the radius except at its distal end and this vein is frequently figured as if fused with radius. Such a fusion rarely takes place in this order and the error in observation is due to the presence of the subcostal furrow. The subcosta lies ventrad of the radius throughout the greater part of its course. The subcostal furrow occupies a prominent position in the stiffening of the cephalic margin of the wing and in the Odonata this furrow is held open and its position preserved by the development of the cross-veins into transverse trusses.

Nodal.—The nodal furrow is the transverse furrow located at the distal end of the subcostal vein in the Odonata. Its position on the cephalic margin is marked by a distinct notch.

Costal Hinge.—The thin area in the front margin of the mesowings of certain Hymenoptera is known as the costal hinge. It is situated between the distal end of the costa and the proximal end of the stigma and is believed to represent the membranous portion of the costal margin of the wing between costa and Sc_2 that is unsupported and unoccupied by a vein. The costal hinge is distinct in the Tenthredinoidea but in specialized Hymenoptera is obscured by the complete chitinization of this region. The costal hinge has been confused with the nodal furrow with which it has absolutely no relation.

Radial.—The radial furrow is a broad one. It is of general occurrence in hymenopterous wings and, when fully formed, crosses all the branches of radius lying caudad of R_3. Its presence is indicated by clear spots in the veins that have been termed bullae by some writers. The bullae are spots where the coloring matter is wanting for the most part and the wing-membrane is not nearly so strongly chitinized. The radial furrow is sometimes short and connected with the medial furrow.

Medial.—The medial furrow is also of general occurrence in hymenopterous wings. It arises in the cell R_5, crosses the vein M_{1-2}, passes toward the distal end of the wing, and crosses the free part of M_2 near its cephalic end. In the Hemiptera it separates the embolium from the remainder of the wing.

Cubital.—In the heteropterous Hemiptera there is a prominent furrow located in the mesowings between the media and the cubitus, the cubital furrow, along which the wing is folded. This furrow is also known as the claval suture.

Anal.—The anal furrow is present in the wings of many insects. It is especially well marked in the wings of hymenopterous insects and is situated between cubitus and the first anal vein. In the Diptera the anal furrow of certain authors is vein VIII of Redtenbacher, the true first anal vein.

Second Anal.—The second anal furrow is found in the metawings of certain Hymenoptera. It is located caudad of the second anal vein and reaches the wing-margin at the axillary incision. This furrow is also distinct in both wings of the homopterous Hemiptera, where it is known as the claval suture.

Wing-thickenings.—The wings of certain insects contain thickenings which bear no relation to the longitudinal veins, cross-veins, or furrows. The following need to be noted:—

Spurious Vein.—The wings of most species of the dipterous family Syrphidae contain a prominent thickening located between the radius and media. It extends across the radio-medial cross-vein and is known as the spurious vein.

Stigma.—The wings of many insects contain a prominent thickening in the distal part of the cephalic margin. This thickening is known as the stigma. It is prominent in the mesowings of most Hymenoptera and is bounded by the wing-margin, Sc_2, and R_1. The stigma is triangular in outline in the Corrodentia and is bounded by the wing-margin and R_1. It is a prominent area in most Odonata, located nearly midway between the nodus and the apical angle, and bounded by the wing margin and Sc_2+R_1. Some dipterous insects contain a slight thickening comparable to a stigma.

Union of Wings.—A synchronous motion of the two wings of a side is secured in many insects by a fastening of some sort. The form of this fastening usually varies with the order. That greater efficiency would result from a fastening of the two wings of a side would seem self-evident, nevertheless there are no more efficient fliers among insects than are found in the order Odonata where the two wings do not bear special structures for fastening them together, neither is there an overlapping of the wings.

Frenulum.—The wings of most moths are fastened together by a single strong seta or several large setae which are attached to the humeral angle of the metawing. Each of these types is known as a frenulum. The single strong seta is typically characteristic of the male and the several large setae of the female. In the females of a few families the large setae are united into a bundle, forming a single strong seta, like that of the male.

Frenulum Hook.—The ventral surface of the mesowing of many females contains a cuticular lobe in which the end of the

frenulum fits, fastening the two wings together. This lobe is known as the frenulum hook and in many moths is apparently formed of scales.

Jugum.—The moths of the suborder Jugatae have a finger-like lobe on the caudal margin of the mesowing which fits on the ventral side of the metawing, fitting thumb and finger-like around the costal margin of the metawing. This finger-like lobe is known as a jugum. It is stiffened by one of the branches of the third anal vein. In museum specimens the jugum frequently rests upon the dorsal surface of the metawing.

Fibula.—There is in certain insects a projection or lobe on the caudal margin of the mesowing which fits over the dorsal surface of the metawing. This structure, first described by Comstock, he has named the fibula. It is of quite common occurrence among the Trichoptera. The caudal margin of the metawing of this order is also sometimes produced jugum-like.

Humeral Angle.—Among the butterflies and large moths the frenulum is wanting and the humeral angle of the metawing is greatly enlarged and projects under the caudal part of the mesowing, insuring a union of the two wings as efficient as the frenulum. In the Lepidoptera the humeral angle is usually supported by one or more humeral veins, which are secondary veins arising from subcosta. A similar method of uniting the wings is found in the order Ephemerida where the metawings are very small.

Hamuli.—The two wings of a side are fastened together by a row of hooks, the costal hooks or hamuli, which are located on the costal margin of the metawing and fit into a fold in the anal region of the mesowing. This fold is a characteristic feature of those wings fastened together with hamuli and is known as the anal fold. The hamuli are of general occurrence on hymenopterous wings, varying from a few to a large number in generalized species, sometimes forming a complete row, but usually represented by only a few hooks near the end of subcosta.

Preparation of Wings.—The wings should be separated from the body with a sharp needle, an embryo-knife, or a good sized mourning pin. It is important that all the proximal portion of the wing should be removed. If the wings are flat, they need only be placed in a clearer, as carbol-xylol, for about fifteen minutes until they are thoroughly cleared. If the wings are large and strong, they can be placed on the slide with the forceps. It will be found better in most cases to place the end of the slide in the clearer and to draw the wings over the end of the slide onto its surface with the forceps. This has the effect, if there are any folds in the wing, of

straightening them out. The anal angle of the metawing is frequently folded beneath the preanal portion. The anal fold can frequently be straightened by holding the wing against the side or bottom of the container holding the clearer and brushing out the fold with a camel's-hair brush. While dragging the wing over the end of the slide will in most cases straighten out the fold if attention is given to this point, yet some refractory wings will not yield even to this treatment. The anal angle of such wings can frequently be unfolded by placing the wing with the ventral side uppermost on the slide and brushing out the fold with a camel's-hair brush and holding it in this position until the tendency to fold is lost. The wing should then be returned to the clearer and placed on the slide right side up. Dissecting needles should never be used in handling the wings because the membrane is delicate and easily torn. The wings should all be placed on the slide with the proximal end of the wing to the right, if they are to be studied with a compound microscope, but if not, the proximal end should be placed to the left. In order to accomplish this, if wings from the proper side of the body are not available, those from the other side should be used and mounted with the ventral aspect uppermost. There is one advantage in mounting the wings with the ventral aspect uppermost and that is that the veins always show more distinctly upon this aspect. The veins of the ventral aspect of the wings of the Lepidoptera can frequently be identified, at least the larger veins, without bleaching the wings or other treatment. Before placing the balsam on the wings, see that there are no air-bubbles under them. The entire space beneath the wing should be filled with clearer otherwise air-bubbles are likely to be present in the mounted wing. The Canada balsam used in the mounting should be thin. If the entire space under the cover is not quite filled with balsam when the cover-glass is added, drop some near the edge of the cover and it will run under and fill the space. After a few days the xylene of the balsam will have evaporated and left a vacant space under the cover. This can be filled in the same way. When the mounting is completed, the slide and the specimen from which the wings were removed, particularly in the case of the Lepidoptera, should be labelled in such a manner that their relation will not be lost or confused. This is most readily done by affixing the same number to the slide and the specimen.

If the wings are badly folded or rumpled, they can be straightened by dropping them on the surface of hot water, being careful, when they come in contact with the water, that they do not rupture the surface-film, for if they do, the water will rumple the

wings and leave them in a still worse condition. If the wings are badly folded and the hot water will not straighten them, remove them from the water and allow them to dry, for wet wings are more liable to rupture the surface-film, and then drop them on the surface of hot water containing eight or ten drops of a ten per cent solution of caustic potash. If the wings are allowed to remain too long in this solution, the caustic potash will remove the color from the veins. When the wings are straight, they should be removed from the water by drawing them onto a glass-slide or a stiff piece of paper. They can then be floated from the slide or paper into a watch-glass of ninety-five per cent alcohol and dehydrated, later cleared and mounted in the usual way.

Method of Study.—The object of this study is to give training in tracing the homology of the wing-veins of the different orders of insects, familiarity in the use of the Redtenbacher system of nomenclature, and illustrations of easily observed lines of specialization. The best method of acquiring this knowledge is for the beginner to draw mounted wings of each form to be studied and then to label the veins, cross-veins, and cells. If a large series of wings representing various lines of modification and several orders of insects are to be examined, a considerable amount of time will be consumed in making the drawings. While it is very desirable that an intimate acquaintance with actual wings should be acquired, a familiarity with the lines of modification that may be present and an ability to interpret them correctly is considered more essential. This knowledge can be acquired from a study and labelling of blue-prints of photographs of actual wings, blue-prints of drawings of wings, or drawing of wings reproduced by means of a hectograph or similar method. The drawings to be labelled should all be made to the same scale, six or seven inches long, regardless of the size of the wings. Drawings of this size are more easily compared and the finer details of the venation stand out more distinctly. They should all be represented with the proximal end of the wing to the left. It is difficult to compare wings, some of which are drawn with the proximal end to the left and others with it to the right. If blue-prints are used and they are inked with waterproof ink, the blue of the blue-prints can be bleached out by the use of a saturated solution of potassium oxalate. After washing for a short time in water, the sheets of drawings should be hung up by the corner to drain and dry. Considerable space should be left between the individual sheets.

It is assumed that the figure of the hypothetical wing-type has been copied, the veins labelled, the cross-veins added and labelled,

and the cells labelled. Beginning at the proximal end of the first wing to be studied, the identity of the stem of each of the primary veins should be determined and labelled. It should be a simple matter after having determined the identity of the stems of the veins to follow each of the branches to the margin of the wing, determine their identity by a comparison with the hypothetical type, and label them. If any of the branched veins contain fewer veins than the same vein of the hypothetical type, it will be necessary to decide what veins are lacking and what has become of them. When the stems and branches of the longitudinal veins have all been accounted for, such cross-veins as are present should be identified and labelled. An ability to correctly label the proximal and distal portions of all the veins of a wing does not necessarily imply a clear understanding of the venation of a wing. The complete course of each vein should be determined by drawing a pencil along all its parts until a clear mental picture of the entire venation has been acquired. The cells should now be identified and labelled. The completely labelled drawing should be shown to the instructor and when passed as correct, the drawing should be inked. Red ink should be used for media and its branches and black for all the other veins including the cross-veins. When any of the branches of media are fused with a vein of another system, this should be indicated by two clearly adjacent lines, a red line for media and a black line for the other vein.

The second wing should now be inspected and the same procedure should be followed, except that the comparison should be made not only with the hypothetical wing-type but also with the wing just completed. All the succeeding wings should be examined in a similar manner. The wings presented for study should be arranged in an ascending series. Such an arrangement should illustrate the development of the dominant lines of modification present in the wings. It will be found after a few wings have been studied that they differ so markedly in the arrangement of their veins and cross-veins from that of the hypothetical wing-type that more help can be obtained by a comparison with the wings just completed. The lines of modification should be traced, if possible, in each case to the hypothetical wing-type. After sufficient wings have been studied and ability has been acquired in determining the lines of modification, several wings should be issued by the instructor at one time. The student should be required not only to determine the homology of the veins and cells, but to arrange the wings in various ways so as to show not only the dominant but other lines of modification.

SPECIALIZATION BY REDUCTION

The hypothetical wing-type is believed to represent the maximum number of veins present in the wing of the original progenitor of insects. Only a few species approximate in number and arrangement the generalized condition found in the hypothetical wing-type. Some of these generalized forms have been preserved in the larger orders, which makes it possible to determine the line of specialization in the different groups. Assuming that the hypothetical wing-type represents the maximum number of veins present in the wings of the original progenitor of insects, the orders can be arranged in two groups. The first group includes those in which there is a "reduction in the number and complexity of parts," wings that have been modified through specialization by reduction, that is, there are fewer veins than in the hypothetical wing-type. This group includes the orders Lepidoptera, Diptera, Hymenoptera, Corrodentia, and Coleoptera. The second group includes those orders in which there is "an addition or complication of parts, specialization by addition," that is, there are more veins than in the hypothetical wing-type.

The wings showing specialization by reduction are better suited for initiating a study of wing-venation than those showing specialization by addition, because the wings of this group approach more closely to the condition found in the hypothetical wing-type or at least their more generalized members. The number and position of the longitudinal veins and cross-veins are more definite and it is easier for the beginner to make comparisons directly with the hypothetical wing-type.

1. LEPIDOPTERA

Lepidopterous wings are characteristic in form. The distal portion is broadly rounded, the metawings more rounded and broader than the mesowings. There are always, when wings are present, two wings on each side of the body. In order to produce an organ for the most efficient type of flight, these wings need to be transformed so that they will approximate a triangle in form, one side of the triangle forming the costal margin, one side the outer margin of the wing, and the third coinciding with the proximal end of the wing. The two wings of a side must be fastened together to secure union of motion. This is secured either by a jugum, a frenulum, or by an expansion of the proximal part of the cephalic margin of the metawing because of the reduction or loss of the frenulum. The wings are usually sheathed with a dense covering of overlapping corrugated microscopic scales which are

fitted like the shingles on a roof and serve to stiffen the wing in a similar manner. This stiffening of the wing by the scales must also influence the form of the wing and the arrangement of its veins.

Clearing Wings.—The scales covering the wings are opaque, due to the presence of pigment. This makes it impossible to study the arrangement of the veins until the scales have been removed or rendered transparent. The scales can be removed with a small artist's sable-brush. This is not very practical except when it is desirable to examine only a small area of a wing or in the case of small delicate wings that might be injured by chemicals. When all the veins are to be examined, it is better to make the wing transparent. This can be accomplished either by applying a liquid that will evaporate quickly or by using a solution that will remove the color from the scales. Where only a few specimens are at hand and it is desirable to retain them intact as museum specimens and for the study of coloration, the scales can be rendered transparent by wetting them. This can be accomplished by dropping alcohol, benzine, gasoline, ether, or chloroform, preferably the latter, upon the wing. These substances evaporate quickly and do not effect the color or the arrangement of the scales, but allow sufficient time for a cursory examination of the venation. Where it is desirable to make a drawing of a wing showing the venation, the coloring matter of the scales should be removed by the use of a bleaching powder solution. Labaraque solution, which can be procured from any druggist, should be employed. It is only by the use of wings prepared in this way that careful studies, photographs, or careful drawing can be made.

Bleaching Wings.—The wings, if they are to be bleached, should be removed in the way already described. It will be found advantageous, before attempting to remove the wing, to break off the tegula, so as to expose the proximal end. There should be available five glass-boxes, stender jars, 60 mm. X 35 mm., or Petri dishes 90 mm. in diameter. These should be arranged in a row, containing from left to right, commercial alcohol, 10% hydrochloric acid, Labaraque solution, commercial alcohol, and a clearer, preferably, carbol-xylene, made by combining one part by measure of the melted crystals of carbolic acid with three parts of xylol. It is unwise to attempt to carry the wings of more than one species through the bleaching solutions at one time, because of the wings of two species becoming confused.

The wing when removed from the body should be placed in the alcohol to wet it and remove the air from beneath the scales. They should then be transferred to the hydrochloric acid and then to

the Labaraque solution for bleaching. It is impossible to predict how long it will take to bleach any particular wing. Dark wings will take the longest time. While some wings bleach very quickly, five minutes or less, others may require from fifteen minutes to two hours or more. The wings should remain in the Labaraque solution until all the color is removed. If the bleaching proceeds slowly, it can be quickened by returning the wings from time to time, every few minutes, to the hydrochloric acid and then placing them in the Labaraque solution again. The acid liberates the active bleaching element, the chlorine of the Labaraque solution. When the bleaching is completed, return the wing to the left jar of alcohol and with a camel's-hair brush remove all the air-bubbles that have collected upon the two surfaces of the wing. If the bleaching has been thoroughly done, the veins should now be distinct. The wing should then be placed in the right jar of alcohol and left for fifteen to twenty minutes for dehydration. When this is completed the wings should be placed in the clearer and left for the same length of time. When the clearing is completed, the wing should be mounted on a glass slide in balsam. If the wings are to be mounted in glycerin-jelly or damar, they should not be placed in the clearer, but mounted directly from the alcohol. The balsam should be quite thin. In large wings the base is thick and considerable balsam will be needed to fill the space under the cover. If the space is not completely filled after the cover is put in place, some balsam can be dropped at the edge of the cover and it will run under and fill the space. After the slides have stood for a few days, some of the xylol will have evaporated from the balsam leaving empty spaces which can also be filled by dropping some balsam at the edge of the cover. The xylol can be driven off more rapidly by placing the slides on a radiator or in a drying oven. For large wings number two covers should be used, and, if necessary, slides two inches by three inches can be used. If some other clearer than carbol-xylol or one not miscible with commercial alcohol is used, the wings should be dehydrated in absolute alcohol. The mounted wings and the specimen from which they were removed should be numbered in such a way as to tie them together. If desirable the wing after the completion of dehydration can be stained in Gage's Säurefuchsin. When the staining is completed the wing will need to be dehydrated again. Large wings can be stored in shell-vials and studied in a Syracuse watch-glass or Petri dish.

WING STRUCTURES.—The wings of the Lepidoptera possess the following peculiarities that need description:—

Anal Veins.—The Lepidoptera show considerable variation in

the number of anal veins present in their mesowings and metawings. There are typically two unbranched anal veins and a branched vein in each wing, but this number is rarely present in both wings of the same species. The third anal vein is frequently branched or at least the trachea that precedes it. The number of anal veins present in the metawings is usually greater than is found in the mesowings, although in a few cases this is reversed. Still more often, there is the typical number of tracheae, three, present, but veins are not formed about all of them. When there are only two anal veins present, it is usually the first anal vein that is atrophied and when there is only one anal vein present, it is the first and third that are atrophied. The trachea of the third anal vein is generally forked in this order and frequently both branches are represented by veins. When the second anal vein is apparently forked at its proximal end, the caudal part of the fork is the first branch of the third anal vein, 3rd A_1. The caudal branch, when present, is labelled 3rd A_2. The third anal vein and its two branches are designated by some writers on this order as the axillary vein.

Costa.—The costal margin of the metawing is generally not thickened and is, therefore, not vein-like. It is designated, regardless of this fact, as the costa. This condition of the costal margin has led many writers to disregard it and to consider the subcosta as the first vein and label it as the costa.

Subcosta.—This vein in its generalized condition is as shown in the hypothetical wing-type, that is, a two branched vein. This condition is found only in the Jugatae. The wings of the pupae and adults of Sthenopis show conclusively that it is the free part of the subcosta-one that atrophies, as in some species, this vein is present in the wing of one side and wanting in the other, while the size and position of subcosta shows that it is always subcosta-two that is retained. In the hind wings where radius consists of two branches, the first vein is subcosta-two plus radius-one.

Subcosto-radial Cross-vein.—In a few groups of Lepidoptera there is frequently a cross-vein between subcosta-two and radius-one. This cross-vein is the subcosto-radial cross-vein. It is designated as *s-r*.

Sectorial Cross-vein.—In a large group of small moths there is quite regularly a cross-vein between R_3 and R_4 or R_{2+3} and R_{4+5}. This is the sectorial cross-vein, which is designated as *s*.

Media.—The media in both wings consists of three or less branches. A study of the pupal wings of Sthenopis shows a distinct medial trachea which divides near the arculus into two branches.

The cephalic branch divides into M_1 and M_2 while the caudal branch remains unbranched. This represents the fusion of M_3 and M_4 and should be so labelled. Professor Comstock has questioned the correctness of my conclusions on this point but a restudy of the question convinces me that no other interpretation is possible. The trachea which he finds in the mounted wings of adult insects are not the primary tracheae. Not only the arculus, but all the other cross-veins, even the humeral cross-vein, contain fine tracheal trunks. In most Lepidoptera the stem of media is atrophied and the branches of media appear to be parts of radius and cubitus.

Humeral Veins.—Those lepidopterous insects, where the frenulum is replaced by a dilation of the humeral angle of the metawing, often have this region strengthened by one or more short veins which arise from the cephalic margin of the subcosta. These veins are known as the humeral veins, are labelled *hv*, are secondary in origin, and are, therefore, not homologous with the humeral cross-vein although situated in a somewhat similar position.

Discal Cell.—The name of discal cell is frequently applied to the large cell situated on the proximal half of the wing between radius and cubitus. This cell is a compound one, formed by the atrophy of the stem of media, of a part of the medial branches, and a part of the radial sector.

Discal Vein.—The transverse vein forming the distal end of the discal cell is known as the discal vein. It is generally formed of parts of several veins, as, cubitus-one, the medio-cubital cross-vein, parts of the various branches of media, and the medial cross-vein.

Accessory Cells.—One or more closed cells are frequently formed in the mesowings of certain families of moths by the anastomosing of the branches of radius. These cells are known as accessory cells but are always labelled according to the vein forming their cephalic margin.

MESOWINGS

The mesowings and metawings of lepidopterous insects are not modified along the same lines, so that, if the two wings of each side of each species studied are examined, there is introduced considerable material in one wing or the other that offers nothing new and that has no bearing on the line of specialization that the wings are arranged to show. In order to obviate this difficulty and to keep the number of wings to be examined as small as possible, a series of mesowings is examined first to identify the trend of modification in them and then later a series of metawings.

Sthenopis thule.—This pupal wing (Fig. 24, A) shows two things, white bands and black lines upon the white bands. The white bands represent the developing veins and the black lines the tracheae located within the veins. Identify the tracheae by comparing them with the hypothetical wing-type. Label the longitudinal veins and the cross-veins.

Fig. 24.—Mesowings of *Sthenopis thule.* A, pupal wing ; B, adult wing.

Sthenopis thule.—Compare the wing of the adult (Fig. 24. B) with that of the pupa. The pupal wing shows the homology of the veins that are wanting in the adult. Identify the longitudinal veins, the cross-veins, and the cells.

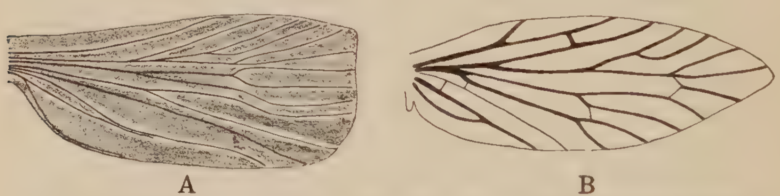

Fig. 25.—Mesowings of, A, *Cydia pomonella*, pupal ; B, *Micropteryx aureatella.*

Cydia pomonella.—A pupal wing that shows the developing veins (Fig. 25, A) and the tracheae. Identify the tracheal stems

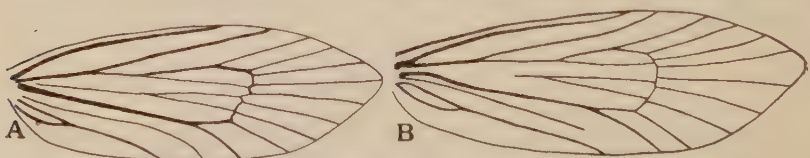

Fig. 26.—Mesowings of, A, *Lampronia quadripunctella* (after Stainton) ; B, *Incurvaria praelatella.*

by comparison with the wings of Sthenopis. Label the veins and cross-veins. This wing is out of place at this point in the series. It explains conditions found in the wing of Micropteryx, of which a pupal wing is not available.

Micropteryx aureatella.—Compare carefully (Fig. 25, B)

with Sthenopis and Cydia. The presence of a subcosto-radial cross-vein is characteristic of this series. The anal region is different from that of Sthenopis. There is a secondary cross-vein present.

Fig. 27.—Mesowings of, A, *Nemotois metallicus*; B. *Enicostoma lobella.*

Lampronia quadripunctella.—Compare (Fig. 26, A) with Micropteryx. This wing, while very generalized, is modified in certain regions.

Incurvaria praelatella.—Compare (Fig. 26, B) with Lampronia. Label the veins, cross-veins, and cells.

Nemotois metallicus.—Compare (Fig. 27, A) with Lampronia and Incurvaria. This wing shows a later stage of modification.

Fig. 28.—Mesowings of, A, *Gelechia subocellea* (after Stainton); B, *Metzneria carlinella.*

Enicostoma lobella.—Compare (Fig. 27, B) with Incurvaria and Nemotois. This wing shows a still later stage.

Gelechia subocellea.—Compare (Fig. 28, A) with Enicostoma, with which it is similar in venation, but the wing is of a different shape.

Metzneria carlinella.—Compare (Fig. 28, B) with Gelechia. The shape of the wing causes the venation to appear differently.

Fig. 29.—Mesowings of, A, *Elachista reuthiana*; B, *Lyonetia clerkella.*

Elachista reuthiana.—Compare (Fig. 29, A) with Gelechia and Metzneria. The modifications found can be derived from either of these wings.

Lyonetia clerkella.—Compare (Fig. 29, B) with Elachista. Note that it shows a more advanced state of fusion than that found in this wing.

Danaus archippus.—The pupal wing (Fig. 30, A) shows tracheae and developing veins. Note especially the relation of the veins to the tracheae. This wing begins a new series.

Danaus archippus.—Compare this adult wing (Fig. 30, B) with the pupal wing. The homology of certain of the veins and of

Fig. 30.—Mesowings of *Danaus archippus*, A, pupal wing; B, adult wing.

the spurs can be determined only from the pupal wing. The conditions found here are characteristic of the butterflies.

Epargyreus tityrus.—Compare (Fig. 31, A) with Danaus. The suppression of the dichotomy of the radius is more complete than in Danaus.

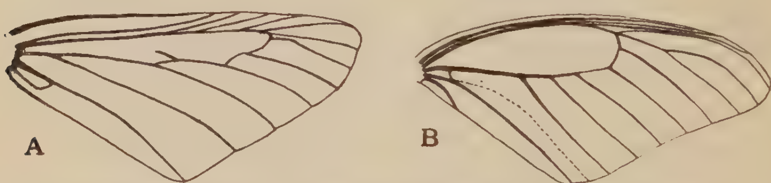

Fig. 31.—Mesowings of, A, *Epargyreus tityrus*; B, *Papilio polyxenes*.

Papilio polyxenes.—Compare (Fig. 31, B) with Danaus. Note the marked difference in the anal region.

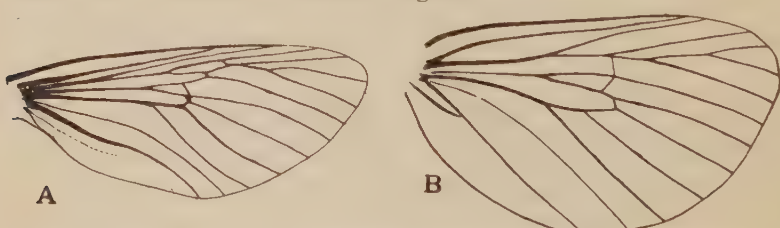

Fig. 32.—Mesowings of, A, *Prionoxystus robiniae*; B, *Parasa indeterminata*.

Prionoxystus robiniae.—Compare (Fig. 32, A) with Sthenopis and Cydia. This wing represents a new series. Note that it contains a different method of suppression of the dichotomy of the radius.

Parasa indeterminata.—Compare (Fig. 32, B) with Prionoxystus. Note the extent of the radius.

Eudule mendica.—Compare (Fig. 33, A) with Prionoxystus and Parasa. Note carefully the serial position of this wing.

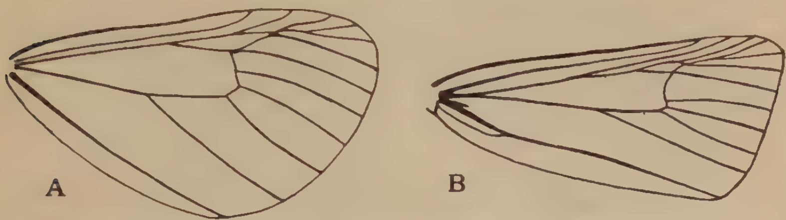

Fig. 33.—Mesowings of, A, *Eudule mendica*; B, *Agrotis ypsilon*.

Agrotis ypsilon.—Compare (Fig. 33, B) with Parasa. The form of the venation and the shape of the wing is characteristic of many lepidopterous wings.

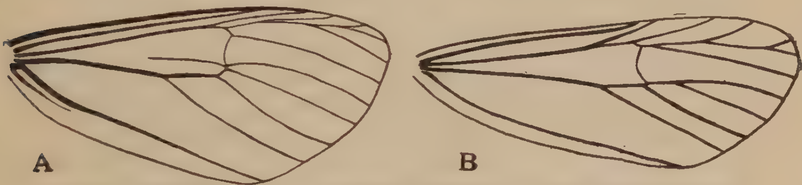

Fig. 34.—Mesowings of, A, *Ctenucha virginica*; B, *Pygoctenucha funera*.

Ctenucha virginica.—Compare (Fig. 34, A) with Agrotis. The difference is not striking.

Pygoctenucha funerea.—Compare (Fig. 34, B) with Ctenucha and Agrotis. Note the arrangement of the veins into two groups.

METAWINGS

The metawings of generalized Lepidoptera are very similar in form and venation to the mesowings, so similar in fact that it is sometimes difficult to distinguish them. But among the specialized Lepidoptera, the metawings are strikingly different not only from the mesowings but from the wings of other insects. They are quite characteristic in form.

Sthenopis thule.—The pupal metawing (Fig. 35, A) is quite similar to the mesowing. Compare the pupal mesowing and metawing and identify the tracheae, the veins, and the cross-veins.

Sthenopis thule.—Compare the adult wing (Fig. 35, B) with that of the pupa. Label the veins, the cross-veins, and the cells.

Micropteryx aureatella.—Compare with the adult wing (Fig. 36, A) of Sthenopis. Compare critically the radial region of the two wings. There are two additional cross-veins present in this wing.

Fig. 35.—Metawings of *Sthenopis thule*, A, pupal wing; B, adult wing.

Mnemonica auricyanea.—Compare (Fig. 36, B) with Micropteryx. All the metawings studied thus far are peculiar in having as many radial branches as the mesowings.

Fig. 36.—Metawings of, A, *Micropteryx aureatella*; B, *Mnemonica auricyanea.*

Danaus archippus.—Identify the stems of the tracheae (Fig. 37, A) in this pupal wing. Follow the branches arising from the

Fig. 37.—Metawings of *Danaus archippus*; A, pupal wing; B, adult wing.

various stems to the margin of the wing and identify them. Compare the radius of Danaus with the radius of any of the preceding

wings and note the difference. Note the independent course of certain of the tracheae. Label the veins and the cross-veins.

Danaus archippus.—Compare the veins in the wing (Fig. 37, B) of the adult with the veins of the pupal wing. Label the veins, cross-veins, and cells. The vein-like projection on the proximal end of subcosta is a humeral vein.

Prionoxystus robinae.—Compare this wing (Fig. 38, A) with that of Danaus. It is much more generalized than Danaus, which

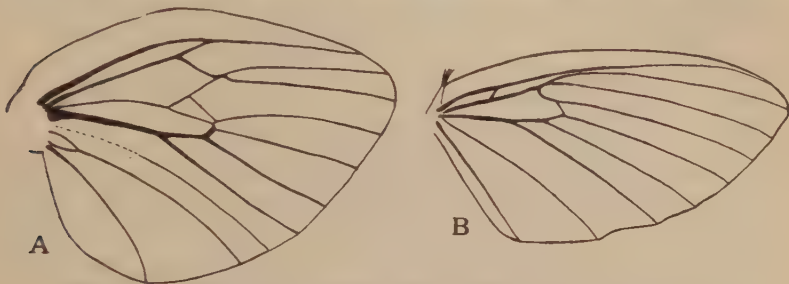

Fig. 38.—Metawings of, A, *Prionoxystus robiniae*; B, *Protoparce sexta.*

is not in its right place in the series because the pupal wing of Prionoxystus is unknown.

Protoparce sexta.—Compare (Fig. 38, B) with Prionoxystus. Considerable modification has taken place.

Cerura albicoma.—Compare (Fig. 39, A) with Protoparce. Cerura is more generalized in certain particulars.

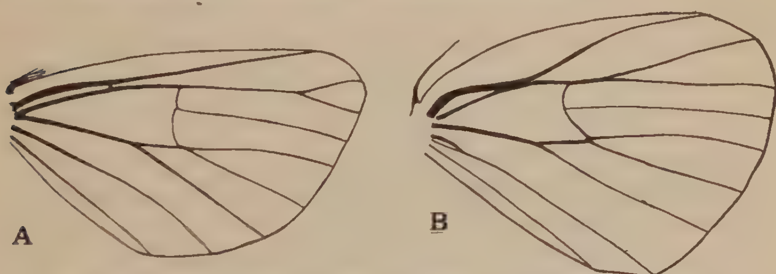

Fig. 39.—Metawings of, A, *Cerura albicoma*; B, *Heterocampa lunata.*

Heterocampa lunata.—Compare (Fig. 39, B) with Cerura. This wing shows a progressive modification.

Hemerocampa leucostigma.—Compare (Fig. 40, A) with Heterocampa, from which it is not strikingly different.

Agrotis subgothica.—Compare (Fig. 40, B) with Heterocampa and Hemerocampa. These three wings are quite similar.

Malacosoma americana.—Compare (Fig. 41, A) with Agrotis. The humeral veins are very prominent.

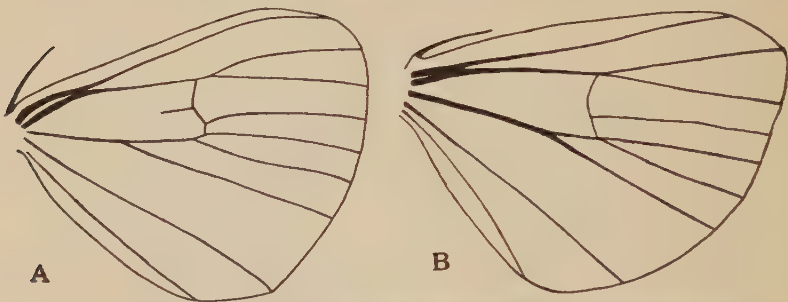

Fig. 40.—Metawings of, A, *Hemerocampa leucostigma*; B, *Agrotis subgothica.*

Psychomorpha epimenis.—Compare (Fig. 41, B) with Agrotis. This wing is related to Agrotis and shows a progressive modification.

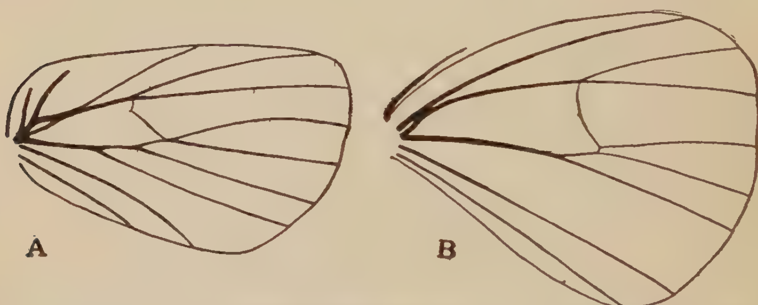

Fig. 41.—Metawings of, A, *Malacosoma americana*; B, *Psychomorpha epimenis.*

Gnophelia vermiculata.—Compare (Fig. 42, A) with Psychomorpha. The fusion of the branches of media and cubitus is

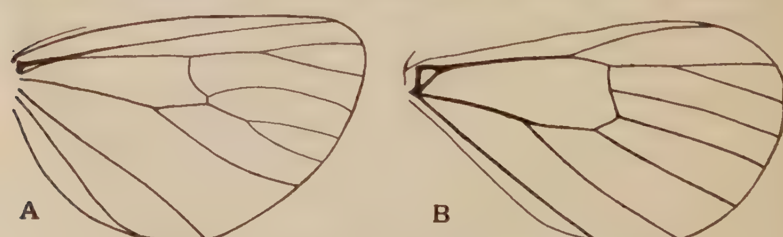

Fig. 42.—Metawings of, A, *Gnophelia vermiculata*; B, *Eudule mendica.*

characteristic. This leads to Pygoctenucha rather than to Eudule and shows one method of the arrangement of the veins into two groups.

Eudule mendica.—Compare (Fig. 42, B) with Agrotis and its allies. The cell at the proximal end of the wing is characteristic.

Pygoctenucha funerea.—Compare (Fig. 43, A) with Gnophelia. Determine the prominent differences.

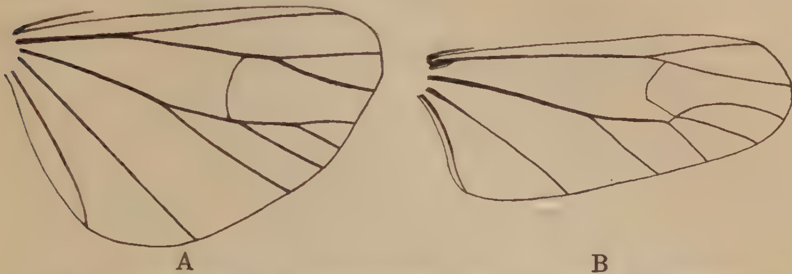

Fig. 43.—Metawings of, A, *Pygoctenucha funerea;* B, *Dahana atripennis.*

Dahana atripennis.—Compare (Fig. 43, B) with Pygoctenucha. Note the fusion of veins.

Lycomorpha pholus.—Compare (Fig. 44, A) with Dahana. Note the progressive fusion of the veins.

Fig. 44.—Metawings of, A, *Lycomorpha pholus;* B, *Cosmosoma auge.*

Cosmosoma auge.—Compare (Fig. 44, B) with Lycomorpha. This wing shows a side line. Identify the modification forming the basis for this statement.

2. DIPTERA

The wings of the Diptera make especially good objects for the study of wing-venation, as the veins are sharply defined and, therefore, easily followed. They show a number of interesting types of modification. The metamorphosis in this order is so complete and complicated and the wings have become so modified in the course of their development, that no data as to the homology of the veins is obtainable from a study of their ontogeny. The tracheae do not enter the wings until after the venation has been laid down, but the generalized members of the order approach so closely to the conditions found in the hypothetical wing-type, that there is no difficulty in determining the homology of the veins.

The members of this order differ from most other insects in

that they have only a single wing on each side of the body. This has resulted in the development of a form of venation characteristic of the order. The wings have been specialized in several directions so that the order can be divided phylogenetically into two large groups by the way in which radius has been modified. Wings of both of these types, the R_{2+3} type where radius two and three are fused and radius four and five are separate and the R_{4+5} type where radius two and three are separate and radius four and five are fused, will be studied. Radius in each type consists of four branches, but, when each is reduced to three branches, although derived in a different way, the two forms are indistinguishable. Wings of the R_{2+3} type are studied first in the following series.

WING STRUCTURES.—The venation of dipterous wings in the generalized members of the order is not strikingly different from that of the hypothetical wing-type. Because of the angles and the different placing of the various fundamental parts of the veins, these wings do not resemble the hypothetical wing-type in appearance. While Tanyderus and Protoplasa differ morphologically from this type only in two minor details, which have been reached through specialization, because of the elongation of the wing, beginners in the study of insect-wings have difficulty in identifying the parts.

Costa.—The costal margin is thickened and costa is apparently always a distinct vein. It is ordinarily a short vein, occupying the proximal half of the costal margin, but in the Tipuloidea it is sometimes considered as extending completely around the margin of the wing and is known as the ambient vein. That all this structure is morphologically costa is very doubtful.

Subcosta.—The primitive two-branched condition of subcosta is typical of the superfamily Tipuloidea. A similar condition is found in Conops. The same is true of the great majority of Diptera where the free part of Sc_2 has been overlooked because of the subcostal furrow. The vein ordinarily labelled as Sc is Sc_1 and should always be so labelled while the branch labelled R_1 is Sc_2+R_1 and should be treated in a similar manner.

Radius.—The primitive condition of radius, five branches, is found in only a few families. There are ordinarily three or four branches but in a few species there are only two branches. This reduction is due in practically all cases to a distal coalescence.

Media.—Media never consists of more than three branches. Comstock has suggested that the secondary cross-vein located in cell M_4 in Protoplasa (Fig. 47) may represent the free part of the vein M_4. Through the courtesy of Dr. Charles P. Alexander, I

have had an opportunity to examine mounted wings of nine of the thirteen described species of Tanyderidae, including all of the three species of Protoplasa. This family includes all those species with the most generalized type of wing-venation and in none of them but fitchii is there such a vein present. The members of this family are the most generalized of the Diptera and several of them contain several cross-veins, which from their position are clearly secondary in origin. The evidence appears to be conclusive that this vein is a secondary cross-vein and not the free part of M_4. It is of interest that the fusion of the fourth branch of media with the third is the usual disposition of this branch in other insects, as the Lepidoptera, and not by a fusion with the first branch of cubitus.

Cubitus.—The primitive condition of cubitus, consisting of two branches, is that found in practically all Diptera. In the specialized Diptera the two branches form a characteristic coalescence with M_{3+4} and the second anal vein.

Anal.—The most persistent of the anal veins is the second. It is present in most species as a prominent vein extending to the wing-margin. It has generally been considered as the first anal vein. The vein or furrow adjacent to the caudal margin of the stem of cubitus, frequently fading out before reaching the origin of the cubital branches. This furrow, identified as a vein by Redtenbacher, as the anal furrow by Comstock and later as the first anal vein, is distinctly vein-like in the Tipulidae and is considered as the first anal vein. The third anal vein is present as a two-branched vein in the species of Tanyderidae and as a distinct unbranched vein in most of the species of Tipulidae and in varying portions in the other families.

Spurious Vein.—There is a more or less distinct thickening located in the cell R and usually extending across the medio-cubital cross-vein into the cell R_5. This thickening is characteristic of most Syrphidae and is known as the spurious vein.

Proximal Spurs.—There are frequently spurs proximad of the region of the arculus in dipterous wings. The greatest number is found in the Tipulidae, as Cladura (Fig. 51), where there are apparently three spurs. The caudal spur, however, is the proximal portion of the three fused anal veins, Cu + A, and is, therefore, not a spur. The spur situated cephalad of Cu + A is known as the anal spur and is labelled *as*, and the spur cephalad of the anal spur is the cubital spur, labelled *cs*. The cubital spur is wanting in the Tanyderidae and all Diptera except the Tipulidae. The anal spur is present in the Tanyderidae and many Brachycera (Figs. 68-71).

Axillary Incision.—There is in the wings of many Diptera a notch in the anal margin of the wing from which an incision, usually of considerable depth, extends. This notch and incision is known as the axillary incision or excision.

Alula.—The small lobe proximad of the axillary incision is known as the alula. It is bounded on the margin by the spiralis which terminates at the axillary incision.

Calyptera.—The two prominent lobes located proximad of the alula in certain specialized Diptera are known as the calyptera. They are derived from the mesocoria and their free margin is bounded by the spiralis. The proximal lobe is the proxacalypteron and the distal, the one adjacent to the alula, is the distacalyptron.

MESOWINGS

The fact that the metawings are always wanting in this order undoubtedly has had a great influence upon the shape of the wings and the character of their venation. The mesowings possess four features worthy of mention, not all of which occur in the same wing, first, the curving of the veins cephalad to support the costal margin; second, the fusion of the veins of the cubito-anal region to support the caudal margin of the wing; third, the development of the characteristic spurs of the proximal end of the wing; and fourth, the curving of the veins near the margin of the distal portion to prevent fraying of the wing-margin.

Tanyderus australiensis.—This is the most generalized dipterous wing (Fig. 45) that I have seen. The free part of media-

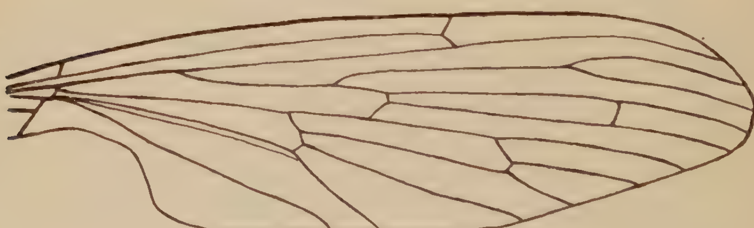

Fig. 45.—Wing of *Tanyderus australiensis.*

four is the only lacking vein. Identify the stems of the veins and then the branches by comparison with the hypothetical wing-type and Sthenopis. There is an extra cross-vein. Label the veins, the cross-veins, and the cells.

Tanyderus forcipatus.—Compare this wing (Fig. 46) with australiensis. They are very similar. There are two additional cross-veins and a spur in forcipatus.

Fig. 46.—Wing of *Tanyderus forcipatus.*

Protoplasa fitchii.—Compare (Fig. 47) with the wings of Tanyderus. This wing is very similar to australiensis. It has an additional cross-vein and a spur. This wing is considered by some as the most generalized dipterous wing.

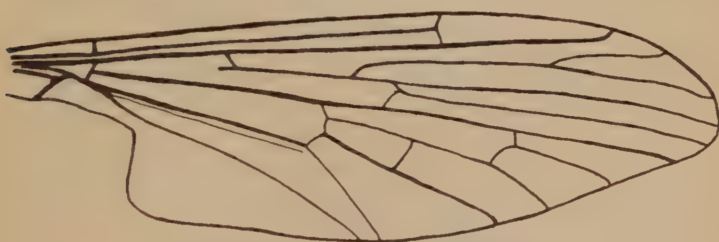

Fig. 47.—Wing of *Protoplasa fitchii.*

Tricyphona protea.—Compare (Fig. 48) with australiensis. Determine the homology of the radial branches, working from the proximal end of the wing. Label the veins, cross-veins, and cells.

Fig. 48.—Wing of *Tricyphona protea.*

Tricyphona calcar.—Compare this wing (Fig. 49) with protea. It is a direct derivative. Remember that longitudinal veins do not

always extend lengthwise of the wing. Protea and calcar illustrate an unusual method of the modification of radius. Has there been a real suppression of the dichotomy? How many cross-veins are present?

Fig. 49.—Wing of *Tricyphona calcar.*

Neolimnophila ultima.—Compare (Fig. 50) with australiensis and protea. Note the additional cross-vein.

Fig. 50.—Wing of *Neolimnophila ultima.*

Cladura flavoferruginea.—Compare (Fig. 51) with Neolimnophila. Note the suppression of the medio-cubital cross-vein and the resultant coalescence. This is a prominent characteristic of tipulid wings.

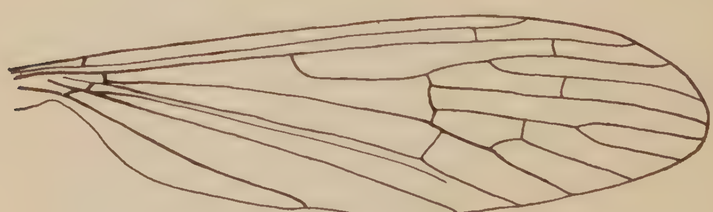

Fig. 51.—Wing of *Cladura flavoferruginea.*

Elephantomyia westwoodi.—Compare (Fig. 52) with Cladura. The medio-cubital region is specialized. Note the completion of the coalescence shown in Cladura.

Bittacomorpha clavipes.—Compare this wing (Fig. 53) with Cladura. The radius is modified in a different way. It is not of

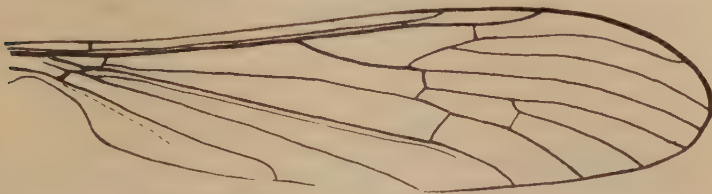

Fig. 52.—Wing of *Elephantomyia westwoodi.*

the nematocerous type. Compare cubitus with Tanyderus. Compare media with Cladura and Elephantomyia. Where is its cross-vein?

Fig. 53.—Wing of *Bittacomorpha clavipes.*

Ptychoptera clavipes.—Compare this wing (Fig. 54) with Bittacomorpha. The radius is of the same type. Media shows

Fig. 54.—Wing of *Ptychoptera rufocincta.*

further reduction. The second anal vein in this genus and Bittacomorpha is represented by a fold.

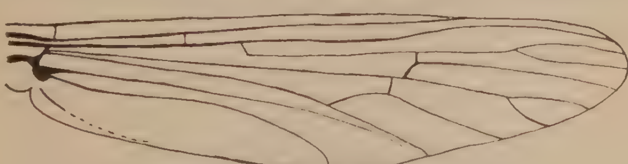

Fig. 55.—Wing of *Culex pipiens.*

Culex pipiens.—Compare (Fig. 55) with Elephantomyia and

Bittacomorpha. Two veins are wanting. The similarity is not analogy, but homology. Note especially the median region. The radius, media, and cubitus show a form and arrangement characteristic of many nematocerous wings. The proximal spurs are greatly reduced. The margin of this wing is fringed with long scales. These have been omitted.

Fig. 56.—Wing of *Dixa fusca.*

Dixa fusca.—Compare (Fig. 56) with Elephantomyia, Ptychoptera, and Culex. All four wings evidently belong in the same series.

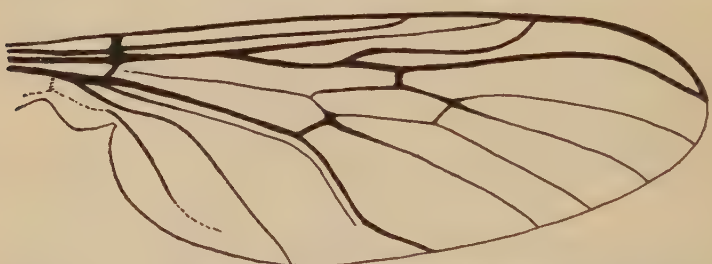

Fig. 57.—Wing of *Rhyphus alternatus.*

Rhyphus alternatus.—The medial region (Fig. 57) is generalized. The radial region is greatly modified. This wing represents a new line.

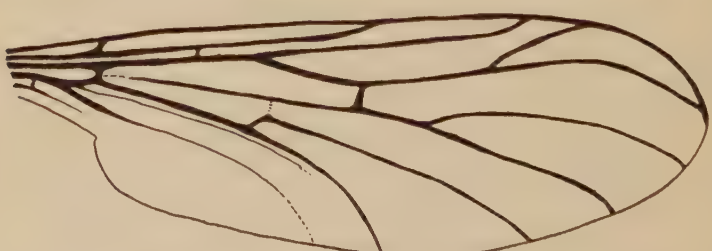

Fig. 58.—Wing of *Hesperinus brevifrons.*

Hesperinus brevifrons.—Compare (Fig. 58) with Dixa. Radius is modified. This wing belongs in a new series.

Mycomyia sequax.—Compare (Fig. 59) with Hesperinus. Note especially the modification of radius.

Fig. 59.—Wing of *Mycomyia sequax*.

Docosia nigella.—Compare (Fig. 60) with Mycomyia. It is a direct derivative. The condition of radius in Mycomyia is derived from Hesperinus and of Docosia from Mycomyia.

Fig. 60.—Wing of *Docosia nigella*.

Pachyrina ferruginea.—Compare (Fig. 61) with Cladura. The branched veins are much shorter. Compare the medio-cubital area with that of Tanyderus. This wing is more generalized than

Fig. 61.—Wing of *Pachyrina ferruginea*.

Cladura and its relatives in certain particulars and more specialized in others. The subcosto-radial region must be examined carefully. This wing begins a new series.

Tipula cunctans.—Compare (Fig. 62) with Pachyrina. This wing is more generalized than Pachyrina. There is a marked shifting in the course of the veins. It is more specialized than Pachyrina in certain particulars.

Fig. 62.—Wing of *Tipula cunctans.*

Brachypremna dispellans.—Compare (Fig. 63) with Tipula. The subcosto-radial region is a modification of that of Pachyrina.

Fig. 63.—Wing of *Brachypremna dispellans.*

The radius and the radial cross-vein are typical. The proximal spurs are exceptionally long and prominent.

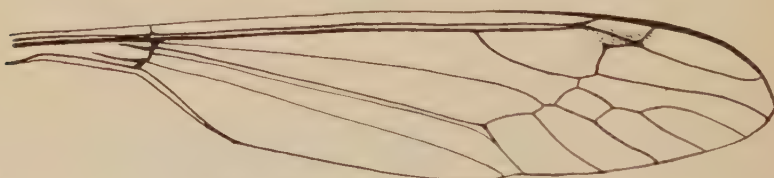

Fig. 64.—Wing of *Megistocera longipennis.*

Megistocera longipennis.—Compare (Fig. 64) with Pachyrina. The subcosto-radial region is a modification of Brachypremna. The

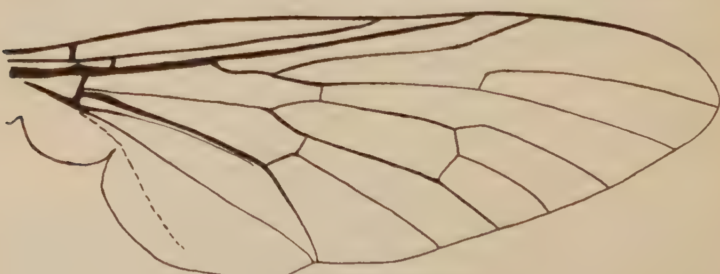

Fig. 65.—Wing of *Leptis vertebratus.*

radial cross-vein is unusual in appearance. The retention of cross-veins in this wing is unusual in this series.

Leptis vertebratus.—Identify the stems of the veins (Fig. 65) and their branches. This is the most generalized wing of its series. Label the veins, cross-veins, and cells.

Fig. 66.—Wing of *Tabanus sulcifrons.*

Tabanus sulcifrons.—Compare (Fig. 66) with Leptis. It is only slightly different.

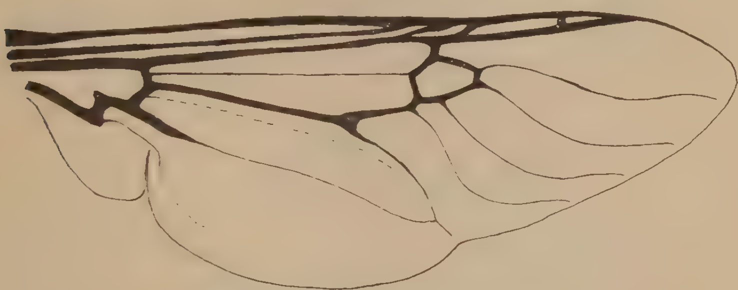

Fig. 67.—Wing of *Stratiomyia apicula.*

Stratiomyia apicula.—The branches have been lost (Fig. 67) through chitinization of the wing-membrane. Compare with Tabanus.

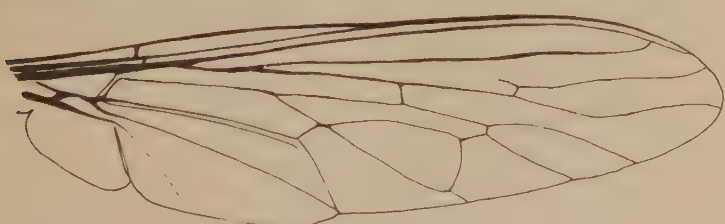

Fig. 68.—Wing of *Erax bastardi.*

Erax bastardi.—Compare (Fig. 68) with Tabanus. Shows an early stage in the modification of the medio-cubital region. The

secondary spur is characteristic. This wing shows an early stage of the modification of the cubito-anal region.

Fig. 69.—Wing of *Eulonchus tristis*.

Eulonchus tristis.—Compare (Fig. 69) with Erax. Note the marginal bracing and the extra cross-vein-like spur.

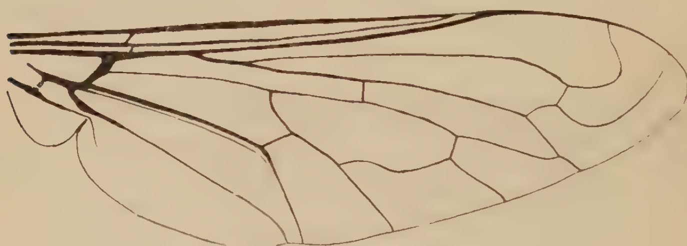

Fig. 70.—Wing of *Pantarbes capito*.

Pantarbes capito.—Compare (Fig. 70) with Erax. Note the marginal bracing and the completion of the medio-cubital changes.

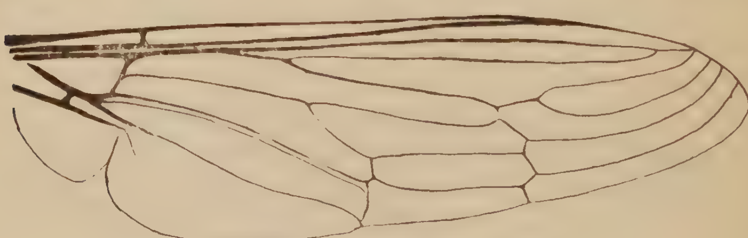

Fig. 71.—Wing of *Rhaphiomydas acton*.

Rhaphiomydas acton.—Compare (Fig. 71) with Tabanus. This wing shows the maximum amount of bracing of the margin and of the wing-membrane.

Midas clavatus.—Compare (Fig. 72) with Rhaphiomidas. The two wings are very similar. The stiffening of the striking edge by the radio-medial region is marked.

Fig. 72.—Wing of *Midas clavatus*.

Rhynchocephalus sackeni.—Compare (Fig. 73) with Rhaphiomidas. This wing is more specialized than Midas.

Fig. 73.—Wing of *Rhynchocephalus sackeni*.

Conops affinis.—Compare (Fig. 74) with Pantarbes. This shows an early stage in the modification of the cubito-anal region.

Fig. 74.—Wing of *Conops affinis*.

Eristalis tenax.—Compare (Fig. 75) with Conops. Note the veins paralleling the wing-margin to prevent fraying. The spurious

vein is characteristic of the family. The prominent bend in the radial region is undoubtedly for support.

Fig. 75.—Wing of *Eristalis tenax*.

Scenopinus fenestralis.—Compare (Fig. 76) with Conops. A later stage in the modification of the cubito-anal region.

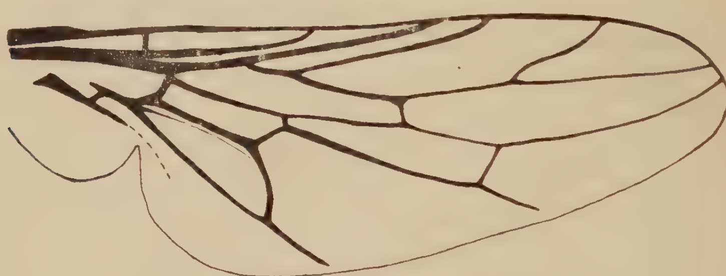

Fig. 76.—Wing of *Scenopinus fenestralis*.

Hilara trivittata.—Compare (Fig. 77) with Scenopinus. A still later stage of modification.

Fig. 77.—Wing of *Hilara trivittata*.

Calliphora viridescens.—Compare (Fig. 78) with Hilara. The modification of the medio-cubito-anal region is complete. Note the reduction in the stems of the veins.

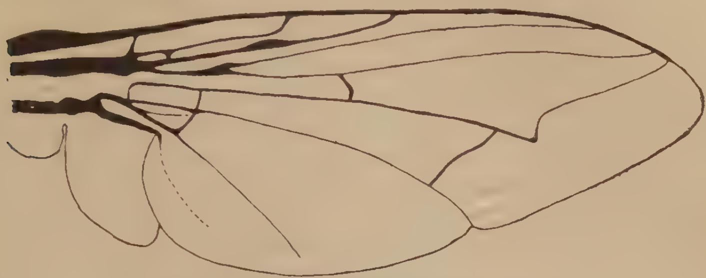

Fig. 78.—Wing of *Calliphora viridescens.*

Psilopus sipho.—Compare (Fig. 79) with Calliphora. Identify the course of the stems of all the veins. Study critically the cells of the proximal end of the wing.

Fig. 79.—Wing of *Psilopus sipho.*

Pelastoneurus vagans.—Compare (Fig. 80) with Psilopus. This is the usual condition found in the wings of this family. Identify the wanting veins.

Fig. 80.—Wing of *Pelastoneurus vagans.*

3. HYMENOPTERA

The wings of hymenopterous insects, although greataly modified and representing a distinct type, can be traced as a direct derivative from the generalized type of dipterous wing. The difference in appearance of the wings of the Hymenoptera from those of the Diptera is due to the great amount of proximal coalescence of the branches of the veins. The free parts of these veins in many cases extend transversely, appear like cross-veins, and have been so considered by most students of the order. The development of cross-veins has undoubtedly resulted from an effort to stiffen the wing against two stresses, the one exerted on the cephalic or striking margin and the other the pull of the metawing. This pull effects the venation of both mesowing and metawing and is due to the fact that the two wings are fastened together by a series of hooks (Fig. 124), the hamuli.

The hymenopterous type is the result of an exceptional amount of coalescence, mainly proximal. The simplest type is found in the wings of the families Xyeliidae and Pamphiliidae. The wings of no known living species contain all the veins. The atrophy of parts of veins inaugurated in the wings of these families is continued in the other families, until in some species the veins are represented by only a few stubs. While the arrangement of the veins characteristic of the Hymenoptera has been brought about by coalescence, the breaking down and modification of this type is due to atrophy alone.

It has already been shown, both by discussion and from the examination of wings, that the arrangement of the wing-tracheae, is of the greatest importance in determining the homology of the veins. From studies made by Comstock and Needham, it has been shown in the case of the Hymenoptera that the wing-tracheae do not enter the wings until after the veins are fully formed. Their account is as follows:—

"The importance of this method of study (ontogenetic) has been well shown by the results we have obtained. We also found that in the Trichoptera there is little correlation between the venation and the tracheation of the wings, a remarkable reduction of the wing-tracheae having taken place. A similar reduction of the tracheae of the wing exists in most families of Diptera; and when even a large proportion of the tracheae are retained, as in certain asilids, they afford little aid in the determining of the homology of the wing-veins. For this reason we omitted a discussion of the tracheation of the wings of the Diptera. Again, in

the Hymenoptera we find that the courses of the tracheae can not be depended upon for determining the homologies of the wing-veins. But here, in the more generalized members of the order, we find a very complete system of wing-tracheae, and it is, therefore, incumbent on us to demonstrate that such a correspondence does not exist."

"In the Hymenoptera, as we have shown, the courses of the branches of the forked veins, in those forms where they have been preserved, have been so modified that these branches extend more or less transversely, making sharp angles with the main stems. It is not strange, therefore, that the tracheae of the wings of the pupae lying free within the wing-sac, have not followed these changes."

"It was found, however, that this is not the explanataion of the change. An examination of the wings of young pupáe of the honey-bee revealed the fact that in this insect the laying out of the wing-venation precedes the tracheation of the wing. After the wing-veins reach that stage of development in which they appear as pale bands, the tracheae grow out from the base of the wing into them.

"It is obvious that tracheae developed in this way will follow the paths offering the least resistance to their progress; and that it is not to be expected that the tracheae will preserve their primitive arrangement under these conditions. This brings us to the conclusion, already announced, that in determining the homologies of the wing-veins in the Hymenoptera we are forced to base our conclusions on a study of the veins themselves, and that a method of study which is of the highest importance in determining the homologies of the wing-veins in many other insects, is of little use here for this special purpose."

Wing Structures.—There are several structures peculiar to hymenopterous wings which need to be described. They are as follows:—

Marginal Vein.—The distal portion of the radial area of hymenopterous wings contains a condition that is peculiar to this order. The veins of this region do not end in the margin of the wing but each extends toward the margin and when adjacent to it bends at a right angle and extends around the periphery of the margin to the next vein caudad of it. This condition is repeated with each vein of the radial area until a heavy vein, a marginal vein, is formed adjacent to the margin and in most cases extends as a blunt projection beyond radius-three. There is consequently a very narrow rim of wing-membrane between the margin of the

wing and the marginal vein. This vein serves not only as a support for this region but prevents a deep fraying of the margin. The blunt projection should be interpreted as a compound of subcosta-two and the radial branches one to three.

Appendiculate Cell.—The veins distad of the stigma, as just pointed out, do not coincide with the wing-margin, that is, there is a narrow margin of membrane between the marginal-vein and the edge of the wing. This condition is particularly noticeable in the Tenthredinoidea. In certain genera this space has been greatly expanded so that the marginal-vein is far distant from the edge of the wing, forming a distinct cell. This cell, which may occur in either mesowing or metawing, does not have a vein on its cephalic margin and can not, therefore, be designated by a bounding vein. It is known as an appendiculate cell.

Bullae.—The wing-furrows have all been described. They are very prominent in the wings of Hymenoptera, particularly the radial and anal furrows. In the radio-medial area, where the radial furrow crosses the veins, there are clear places, where the coloring matter is wanting and the cuticle is not so thick. These clear spots are known as bullae. They undoubtedly accellerate the disappearance of the veins containing them.

Anal Area.—There is a great variation in the extent of the anal area not only among the wings of insects belonging to the different families but also to the two wings of the same side of the same species. The anal area is frequently large and well developed, but may be completely wanting. The anal fold is usually folded beneath the preanal region. In the front wings of generalized Hymenoptera it is small, there is usually a slight indentation, the axillary incision, where the anal fold reaches the wing-margin and one side of the fold is often thickened like a vein. The spiralis is attached along the caudal margin of this lobe and terminates at the indentation. The proximal part of the third anal vein in some wings coincides with the cephalic margin of the line of folding. This probably accounts for the secondary spur on this vein at this point. The spur is very prominent in the hind wings of generalized Hymenoptera. It may represent the remains of 3rd A_2 found in the wings of certain insects. The axillary incision of the front wings is frequently prominent, located opposite the end of the fused anal, cubital, and two caudal median veins. In the hind wings the anal area is generally large and the axillary incision, although varying somewhat in position even among the species of the same family, is well marked.

HYMENOPTEROUS TYPE.—Since the veins of the wings of hy-

menopterous insects are not preceded by tracheae, the homology of the veins must be determined wholly from a comparison of the venation of the adult wings with the venation of the wings of other orders and the hypothetical wing-type. There follows always in homologizing in this way doubt as to the homology of certain parts. Attention has already been called to the fact that practically all the modifications found in adult wings are due to atrophy. The atrophy of veins is evidently due to two very different causes. In the membranous wings of generalized Hymenoptera the atrophy of the veins is evidently due to a shifting in position of the veins to stiffen the stigmatal area and the suppression of needless veins. A very different method exists among certain of the specialized Hymenoptera, where the wing-membrane has been thickened and chitinized and the necessity for veins eliminated. In such wings the atrophying veins can be identified as faint lines extending through the wing-membrane. The following series of hypothetical figures showing the origin of the hymenopterous type as derived from the hypothetical wing-type should do much to simplify the interpretation and homology of the veins in this order.

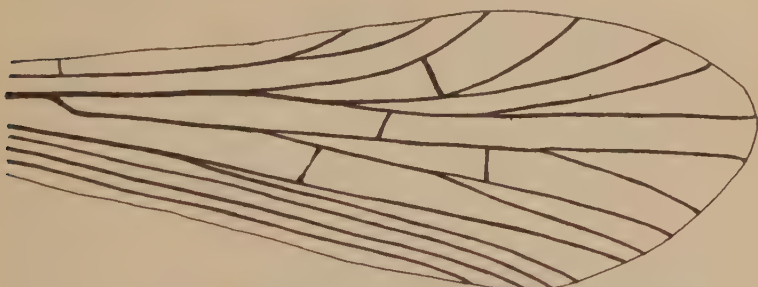

Fig. 81.—Hypothetical Figure-one.

HYPOTHETICAL WINGS

The series of eight hypothetical figures are meant to show the stages in the development of a hymenopterous wing from the condition found in the hypothetical wing-type to that of a generalized hymenopterous wing. The modifications are due to proximal and distal coalescence and anastomosis. These preliminary studies are based upon an examination of the mesowing which shows the most generalized condition. After the modifications peculiar to the mesowing have been identified it will be a simple matter to determine the homology of the veins of the metawing from the homologies established for the mesowing. An attempt has been made in the

discussion of each figure to indicate the basis for the modifications shown by illustrations drawn from other wings. The figures should be studied in sequence and the veins, cross-veins, all transverse veins, and the cells should be labelled.

Figure-one.—The outline of this figure (Fig. 81) is that of a generalized hymenopterous mesowing, Macroxyela. Within this outline all the veins of the hypothetical wing-type are shown. All the cross-veins found in hymenopterous wings are added.

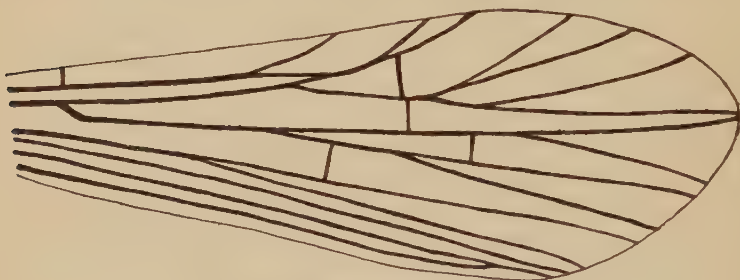

Fig. 82.—Hypothetical Figure-two.

Figure-two.—This figure (Fig. 82) shows the early migration and modifications that take place. The most important is the anastomosis of Sc_2 and R_1. The wings of Pachyrinia, Protoplasa (Fig. 47), Conops, Leptis (Fig. 65), and Tabanus in the order named furnish the evidence for the former anastomosis. The nymphal wing of Nemoura (Fig. 22) also furnishes evidence upon this point. The migration of the veins around the peripheral mar-

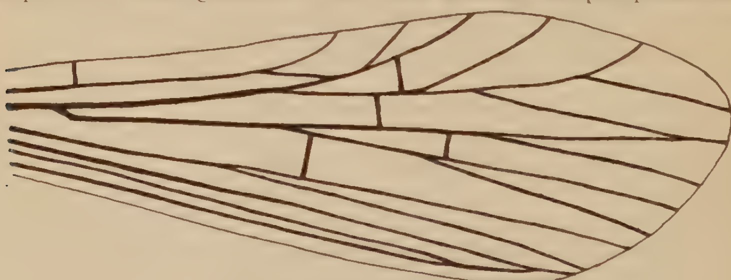

Fig. 83.—Hypothetical Figure-three

gin, as R_5, M_1, and M_4, and the fusion of 1st A and 2nd A are conditions of such frequent occurrence in dipterous wings as not to need especial substantiation.

Figure-three.—A further anastomosis of Sc_2 and R_1 are shown by figure-three (Fig. 83). The anastomosis of radius is now completed, the proximal part of the cell between these veins is squeezed

out and there results a complete suppression of the dichotomy. The proximal coalescence of R_5 and M_1 is paralleled by Pantarbes (Fig. 70), Conops (Fig. 74), and Eristalis (Fig. 75).

Fig. 84.—Hypothetical Figure-four.

Figure-four.—The distal fusion of 1st A and 2nd A (Fig. 84) appears for the first time. The proximal fusion of R_5 and M_1 is continued and R_4 has followed the same course and fused with the combined radius-five and media-four. There is also a fusion of Cu_2 and A.

Fig. 85.—Hypothetical Figure-five.

Figure-five.—This figure (Fig. 85) shows a further distal fusion of radius and media, a proximal fusion of R_5 with $R_4 + M_1$, and the fusion of the first branch of cubitus with $A + Cu_2$.

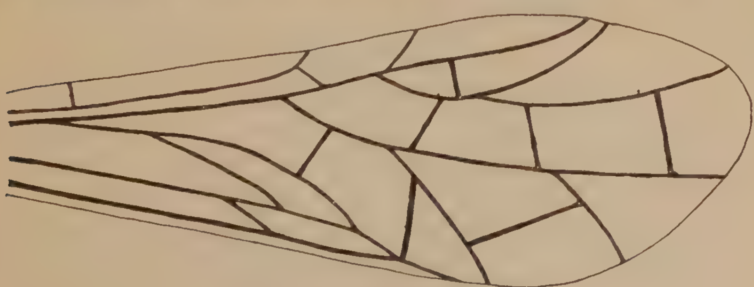

Fig. 86.—Hypothetical Figure-six.

Figure-six.—The position of the free parts of the radial branches are now such that the wing (Fig. 86) begins to take on the appearance of an hymenopterous wing. The cubitus is fused with R + M. The proximal fusion of the cubital and anal veins is paralleled in many dipterous wings. The veins M_{3-4} and Cu_1 are separate in Leptis (Fig. 65) and Tabanus (Fig. 66); fused for a short distance in Erax (Fig. 68), Eulonchus (Fig. 69), Midas (Fig. 72), and Rhynchocephalus (Fig. 73); and fused until the cell

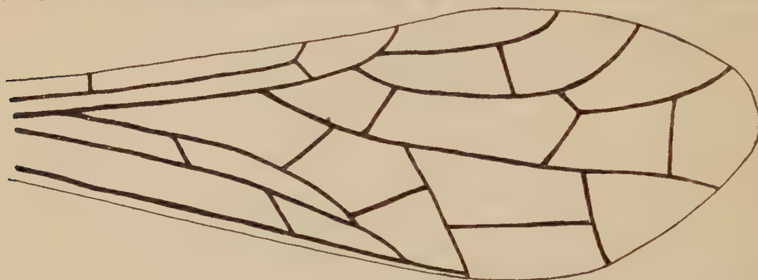

Fig. 87.—Hypothetical Figure-seven.

M_4 is obliterated in Pantarbes (Fig. 70). The veins Cu_2 and 2nd A also undergo several stages of modification. They are separate in Pantarbes; adjacent in Leptis (Fig. 65); fused for a varying distance in Midas (Fig. 72), Erax (Fig. 68), Rhynchocephalus (Fig. 73), Eulonchus (Fig. 69), Tabanus (Fig. 66); and fused for a considerable distance in Conops (Fig. 74), Scenopinus (Fig. 76), Hilara (Fig. 77), and Calliphora (Fig. 78).

Fig. 88.—Hypothetical Figure-eight.

Figure-seven.—While only a slight modification from that given in figure six is shown by this figure (Fig. 87), the straightening of the transverse parts of veins is the most characteristic.

Figure-eight.—This figure (Fig. 88) shows the maximum number of veins that may be found in any hymenopterous wing and more than occurs in any known wing. The insects of the family

Xyelidae always have the free part of R_2 present and the free part of Cu_2 wanting, while the free part of Cu_2 is present and R_2 wanting in certain genera of Pamphiliidae and Siricidae but the wings of no other Hymenoptera possess these veins. A considerable part of the anal veins are present in many species of Tenthredinoidea but in practically all other Hymenoptera they are fused into a single vein.

MESOWINGS

The mesowings of Hymenoptera are more generalized than the metawings, but the latter can be derived from the mesowings. For this reason a series of mesowings are studied first. While the primitive hymenopterous wing undoubtedly arose through coalescence, the modification of the wings of modern species are due in great part to the atrophy of parts of veins.

Fig. 89.—Mesowing of *Pleuroneura avingrata.*

Pleuroneura avingrata.—Compare this wing (Fig. 89) with Hypothetical Figure-eight. It is very similar but lacks the free part on one vein present in the hypothetical wing.

Fig. 90.—Mesowing of *Pamphilius pallimacula.*

Pamphilius pallimacula.—This wing contains the vein (Fig. 90) wanting in the preceding wing. Note the difference in the contour and arrangement of the veins. This wing lacks one vein that is present in Pleuroneura.

Itycorsia luteomaculata.—Compare (Fig. 91) with Pamphilius and Pleuroneura. Determine what veins are wanting. The subcostal region of Pleuroneura, Pamphilius, and Itycorsia are similar.

Fig. 91.—Mesowing of *Itycorsia luteomaculata.*

Xyela modesta.—Compare (Fig. 92) with Pleuroneura and Itycorsia. Study the subcostal region of these wings critically. This wing shows how the modified type of subcosta is derived. The subcosta is wanting in all but the Tenthredinoidea. Xyela and Pleuroneura are closely related.

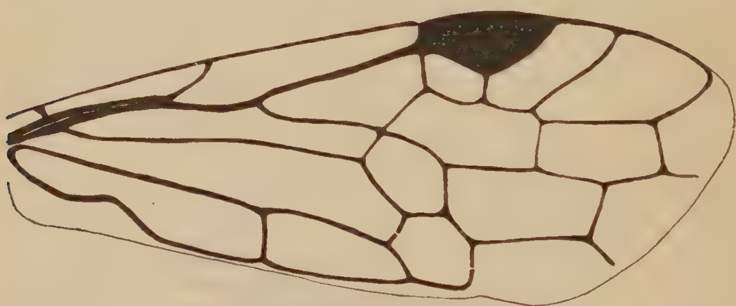

Fig. 92.—Mesowing of *Xyela modesta.*

Strongylogastroidea apicalis.—Compare (Fig. 93) with Xyela and Itycorsia. Note the subcostal and radial regions.

Fig. 93.—Mesowing of *Strongylogastroidea apicalis.*

Strongylogaster annulosus.—Compare (Fig. 94) with Strongylogastroidea. Determine what is wanting.

Fig. 94.—Mesowing of *Strongylogaster annulosus.*

Hemichroa americana.—Compare (Fig. 95) with Strongylogaster and Strongylogastroidea. A continuation of the modification started in Strongylogaster is shown.

Fig. 95.—Mesowing of *Hemichroa americana.*

Periclista melanocephala.—Compare (Fig. 96) with Hemichroa. The identification of the anal cells is important. The condition of the cells C and subcosta-one in Strongylogaster and Periclista is the same, due to the same cause.

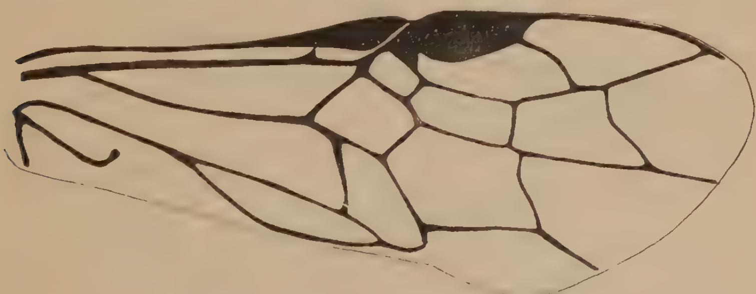

Fig. 96.—Mesowing of *Periclista melanocephala.*

Pteronidea ribesii.—Compare (Fig. 97) with Periclista. This is the end of the line of modifications started in Strongylogaster.

Fig. 97.—Mesowing of *Pteronidea ribesii.*

Hylotoma virescens.—Compare (Fig. 98) with Hemichroa. This wing represents a different line of modification. Identify the extra cell in the radial region.

Fig. 98.—Mesowing of *Hylotoma virescens.*

Loboceras frater. Compare (Fig. 99) with Hylotoma. The condition shown in the cubito-anal region is typical for most wings of this order.

Fig. 99.—Mesowing of *Loboceras frater.*

Megalodontes spissicornis.—Study the radio-medial (Fig. 100) region carefully. Compare with Ityeorsia. This wing begins a new series.

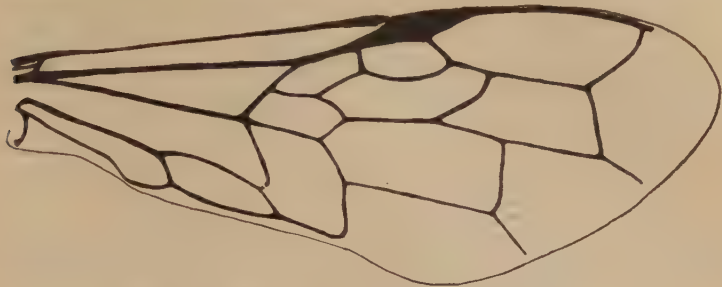

Fig. 100.—Mesowing of *Megalodontes spissicornis.*

Paururus cyaneus.—Compare (Fig. 101) with Pamphilius, Megalodontes, and Hylotoma. This is a generalized wing. The origin of free part of media and position of its cross-vein in Megalodontes and Paururus is typical for most Hymenoptera.

Fig. 101.—Mesowing of *Paururus cyaneus.*

Janus integer.—Compare (Fig. 102) with Megalodontes. The radio-medial region is not like this region in any of the preceding wings.

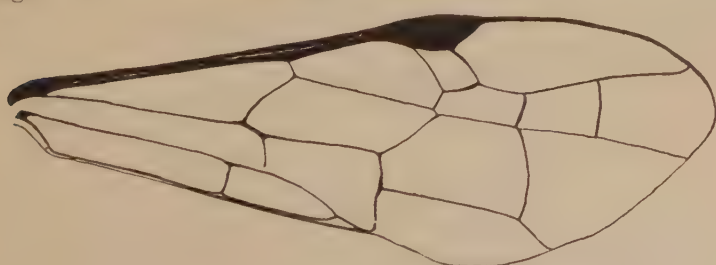

Fig. 102.—Mesowing of *Janus integer.*

Janus abbreviatus.—Compare (Fig. 103) with the wing of integer. This wing is an important intermediate stage in the development of the condition found in the radio-medial region of most hymenopterous wings.

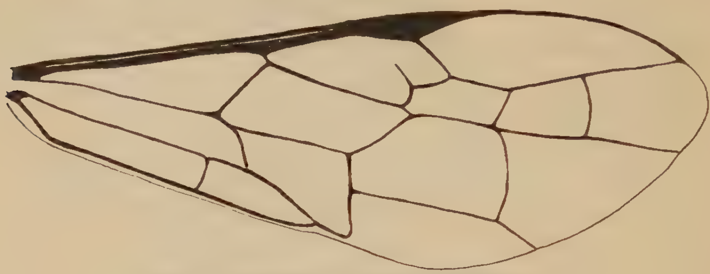

Fig. 103.—Mesowing of *Janus abbreviatus.*

Myzine obscura.—Compare (Fig. 104) with abbreviatus, integer, Megalodontes, and Loboceras. The change is almost complete in the radial region.

Fig. 104.—Mesowing of *Myzine obscura.*

Apis mellifera.—Compare (Fig. 105) with Myzine. The spur, which is not always present, is an important rudiment.

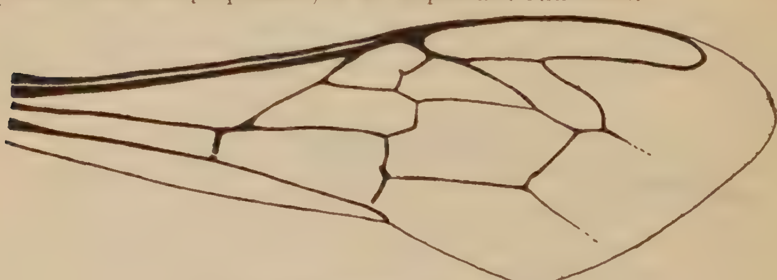

Fig. 105.—Mesowing of *Apis mellifera.*

Sceliphron caementarius.—Compare (Fig. 106) with Apis. This wing completes the type of the series started with Megalodontes. The loss of the proximal part of the radial trunk is com-

pletely effaced and the form of the radial cross-vein is such that its homology would not be suspected.

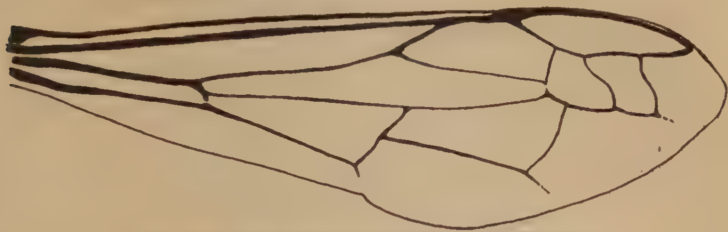

Fig. 106.—Mesowing of *Sceliphron caementarius*.

Vespa maculata.—Similar (Fig. 107) to Sceliphron. The most of the modifications are due to a longitudinal folding or pleating

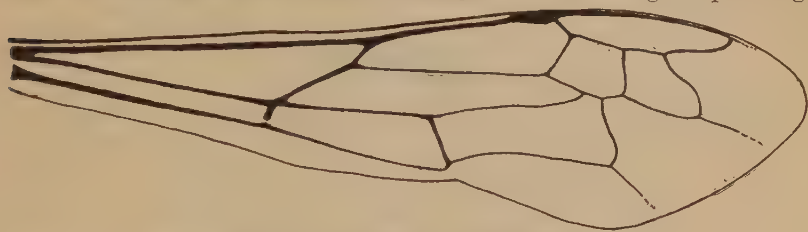

Fig. 107.—Mesowing of *Vespa maculata*.

of the wing. The wing is very long and spatulate.

Notogonia argentata.—Identify the extra cell (Fig. 108) found

Fig. 108.—Mesowing of *Notogonia argentata*.

in this wing. Most of the modifications are due to a general chitinization of the wing-membrane.

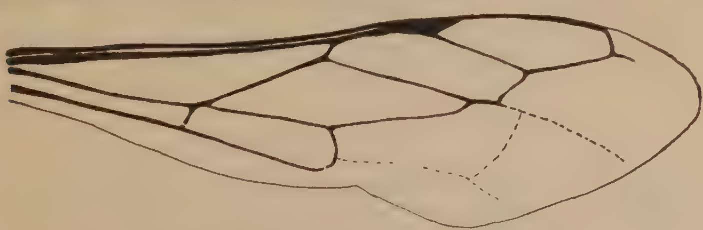

Fig. 109.—Mesowing of *Crabro chrysargyrus*.

Crabro chrysargyrus.—Compare (Fig. 109) with Notogonia. The modifications are due to the same cause.

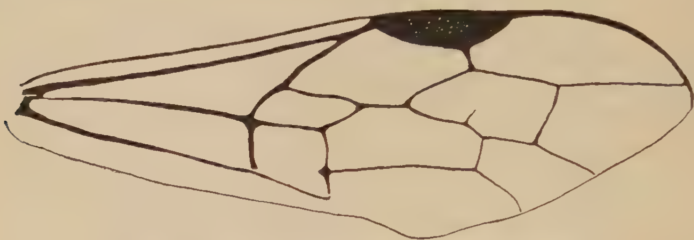

Fig. 110.—Mesowing of *Pammegischia ashmeadi.*

Pammegischia ashmeadi.—Compare (Fig. 110) with Apis and Sceliphron. This wing begins a new series. Examine critically the medio-cubital region.

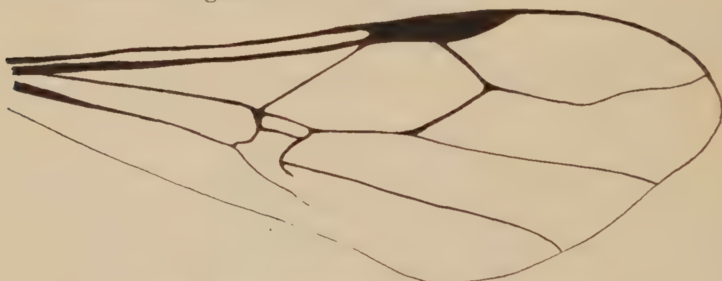

Fig. 111.—Mesowing of *Gasteruption incertum.*

Gasteruption incertum.—Compare (Fig. 111) with Pammegischia. The modifications found are a continuation of those started in Pammegischia. Compare with Pleuroneura and Pamphilius. Could the veins be homologized through such a comparison?

Fig. 112.—Mesowing of *Cryptus americana.*

Cryptus americana.—Compare (Fig. 112) with Pelopaeus and Pammegischia. This is a wing-type characteristic of a large number of species.

Aleiodes terminalis.—Compare (Fig. 113) with Pelopaeus and Cryptus. This is another characteristic type found in many species.

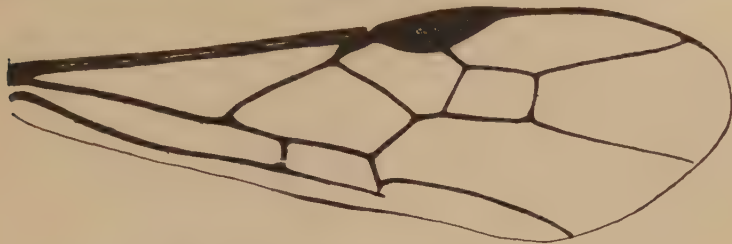

Fig. 113.—Mesowing of *Aleiodes terminalis.*

Chaenon anceps.—Compare (Fig. 114) with Aleiodes. This wing shows a line of modification derived through Aleiodes and

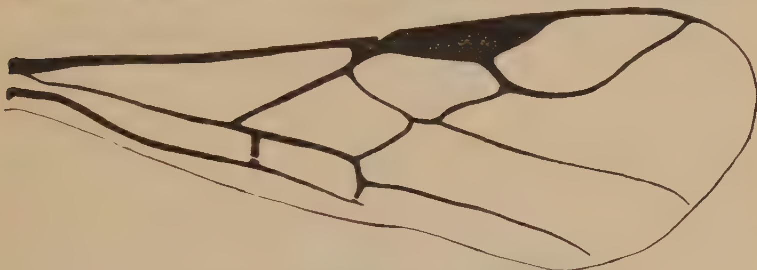

Fig. 114.—Mesowing of *Chaenon anceps.*

does not show the maximum amount of atrophy found in this order. Could the venation of this wing be identified by comparison only with hypothetical figure-eight, Pleuroneura, or Pamphilius?

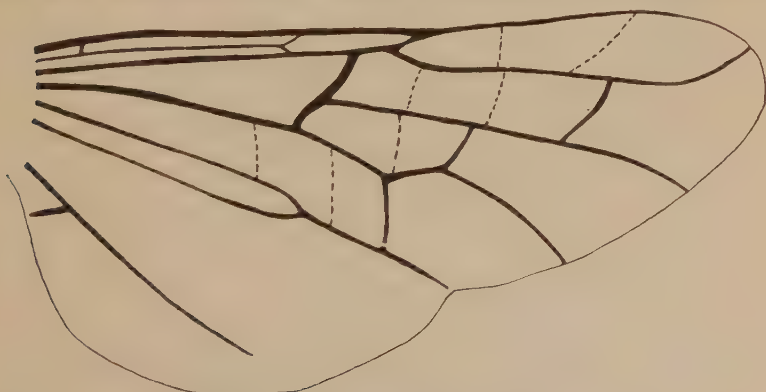

Fig. 115.—Hypothetical Metawing.

METAWINGS

The metawings, even in the most generalized of the Hymenoptera are greatly modified. This change is due in great part to the atrophy of the transverse parts of the veins and to the shifting and changing in position of the parts retained, mostly longitudinal veins.

Hypothetical Metawing.—This figure is based upon a hind wing (Fig. 115) of one of the Tenthredinoidea. The lacking veins are indicated with dotted lines. Label the veins, the cross-veins, and the cells.

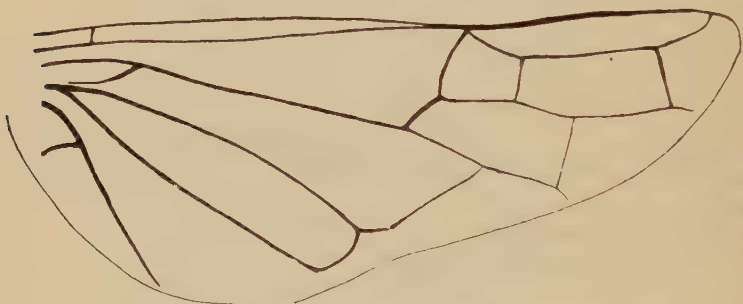

Fig. 116.—Metawing of *Pleuroneura avingrata.*

Pleuroneura avingrata.—Compare (Fig. 116) with the hypothetical metawing. This is one of the most generalized metawings known.

Fig. 117.—Metawing of *Itycorsia luteomaculata.*

Itycorsia luteomaculata.—Compare (Fig. 117) with Pleuroneura. Examine carefully the subcosta, the radius, and the media.

Strongylogaster annulosus.—Compare (Fig. 118) with Itycorsia. Study the subcostal region.

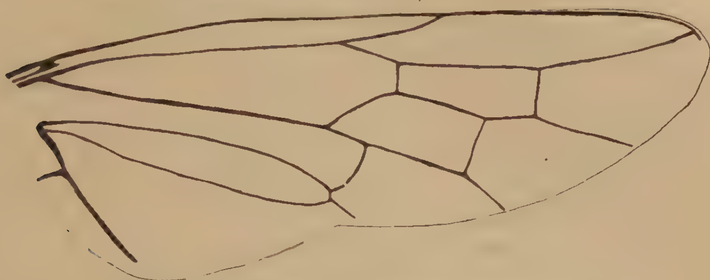

Fig. 118.—Metawing of *Strongylogaster annulosus.*

Periclista melanocephala.—Compare (Fig. 119) with Strongylogaster, from which it shows a common type of modification.

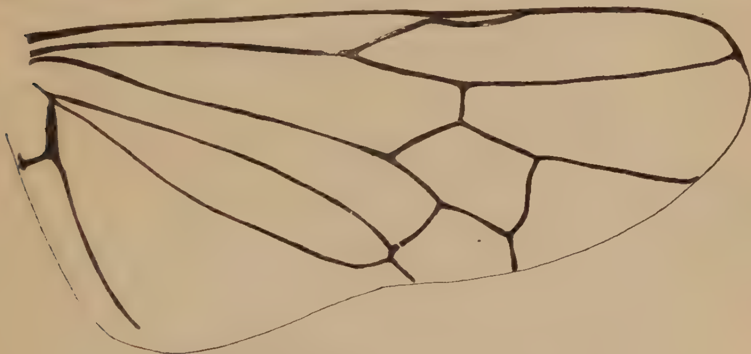

Fig. 119.—Metawing of *Periclista melanocephala.*

Loboceras frater.—Compare (Fig. 120) with Strongylogaster and Periclista. An unusual type of modification.

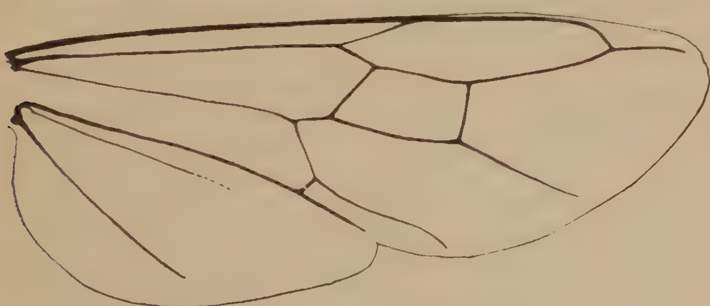

Fig 120.—Metawing of *Loboceras frater.*

Metallus bethunei.—Compare (Fig. 121) with Periclista and Loboceras. It represents an opposite type from Loboceras.

Fig. 121.—Metawing of *Metallus bethunei.*

Cryptus americanus.—Compare (Fig. 122) with Metallus. The changes are due to a migration of the veins and a narrowing of the wing.

Fig. 122.—Metawing of *Cryptus americanus.*

Sceliphron caementarius.—Compare (Fig. 123) with Cryptus. The most important factor producing changes in this wing is migration. The metawings of Cryptus and Sceliphron are characteristic of a large number of wings.

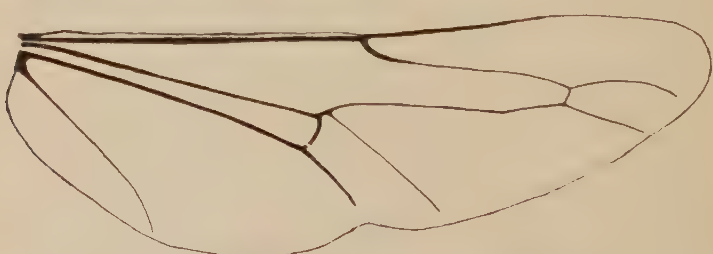

Fig. 123.—Metawing of *Sceliphron caementarius.*

Apis mellifera.—Compare (Fig. 124) with Sceliphron. This wing shows a common intermediate type of modification.

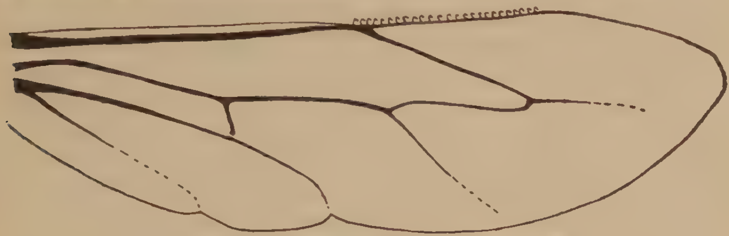

Fig. 124.—Metawing of *Apis mellifera.*

Aleiodes terminalis.—Compare (Fig. 125) with Sceliphron and Apis. This wing is a modification from the wing of Apis.

Fig. 125.—Metawing of *Aleiodes terminalis.*

Aspilota ruficornis.—Compare (Fig. 126) with Aleiodes. This type of wing is the result of atrophy.

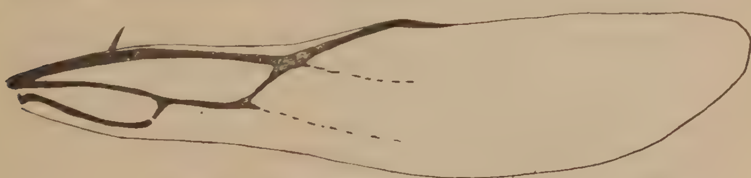

Fig. 126.—Metawing of *Aspilota ruficornis.*

SPECIALIZATION BY ADDITION

The wings in many of the insects of the orders which are very generalized, at least so far as other structures of their bodies than wings, contain many cross-veins and secondary longitudinal veins. This is especially marked in the case of the wings of the order Orthoptera, particularly the various species of cockroaches, the family Blattidae. The other structures of the body of one of the species has been used throughout this study as a type of a gen-

eralized condition. There is, consequently, a fundamental reason, why some students of the venation of insects should consider the primitive wing of an insect as one that contained many veins, always more than are found in the hypothetical wing-type. The recapitulation of the conditions of the hypothetical type by the tracheae of the early nymphal stages of many insects having a large number of veins in the adult offers the strongest evidence that the hypothetical wing-type is near in form and venation to the primitive wing-type. The insects of the following orders have wings with additional veins: Orthoptera, most Plecoptera, Ephemerida, Odonata, many Hemiptera, Neuroptera, Mecoptera, and Trichoptera.

The wings of three orders have been studied where there has been a reduction in the number of veins found in the hypothetical wing-type. It is desirable that representatives of at least one order showing a specialization by addition in the number of veins should be studied. The wings of the orders having additional veins vary greatly among themselves, some have only a few secondary branches and a few secondary cross-veins, while some have an immense number of additional longitudinal veins and cross-veins. These additional veins originate in different ways in the different orders.

1. ODONATA

The wings of the order Odonata have been selected because it is a well known group, one in which considerable information regarding the development of the nymphal wings is available, while the wings themselves contain many features of great interest. Where the number of veins is considerable, it is often difficult, unless the tracheation of the nymphal wings can be followed, to determine the homology of the primary veins and to differentiate them from the secondary veins. Our knowledge of the tracheation and venation in this order is such, that it makes an excellent starting place.

Wing Structures.—The wings of this order like those of the other orders contain some structures which need to be described.

Stigma.—The strongly chitinized area at the distal end of the costal margin of the wing is the stigma. It is usually two or more times as long as broad and is frequently supported by some oblique cross-veins located in the area immediately caudad of the stigma. The stigma serves as a support for the striking edge of the wing.

Nodus.—One of the most striking features of the wings of dragon-flies is the notch near the middle of the costal margin. This notch is known as the nodus. It is the point where costa and subcosta-one terminate.

Arculus.—The arculus and its modification have already been described (Fig. 23). In the order Odonata the arculus is well developed and definite in form. It will be readily identified from its position in the wings of the insects previously studied. The two veins terminating near the middle of the arculus are two branches of media, the caudal one, media-four which has been completely split back in many wings.

Supertriangle.—The triangular cell located distad of the arculus and caudad of media-four is the supertriangle. It is also known as the supratriangular space.

Triangle.—The triangular cell located caudad of the supertriangle is the triangle. It varies somewhat in size and direction.

Anal Loop.—Due to the shifting and rearranging of the veins of the anal region of the wing, particularly in those species where this region has been greatly expanded, there is formed sometimes a circular or foot-shaped or stocking-shaped area of cells. This area is known as the anal loop.

Subnodus.—There are a series of three veins extending caudad from the costal margin at the nodus, the first portion is subcosta-one, the second portion is subcosta-two and may be straight or obilique but is usually straight, while the third portion is apparently always oblique. This third portion is known as the subnodus.

Bridge.—The longitudinal vein located caudad of the caudal end of the subnodus is known as the bridge. It is secondary in origin and is derived in two very different ways as will be seen later. The distal end of the bridge always terminates at what is apparently an oblique cross-vein. This oblique vein is in reality a part of the radial sector.

Radial Sector.—The radius in the Odonata consists of two branches, radius-one and the radial sector. The tracheae about which the radial sector is formed changes in position from cephalad of media-one in young nymphs to caudad of media-two in adult nymphs. The formation of the bridge, which forms a proximal support of the radial sector and appears to be its direct continuation toward the proximal end of the wing, is due to the change in position of the sector.

MESOWINGS AND METAWINGS

Gomphus descriptus.—Study this young nymphal wing (Fig. 127, A) and identify the stems of the tracheae and their branches by comparison with the hypothetical wing-type. Some of the vein-systems are similar in form to those of the wing-type,

others have the full number of branches but the branches are differently arranged, and still others have the number of branches greatly reduced.

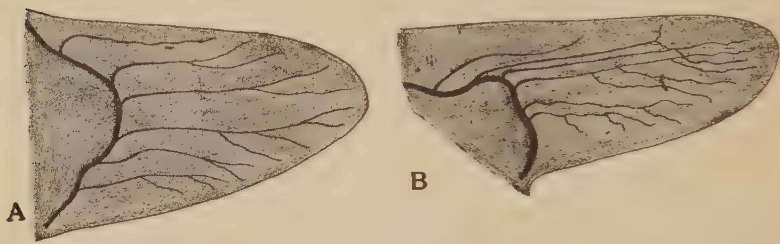

Fig. 127.—Nymphal metawings of *Gomphus descriptus*. A, first stage; B, second stage.

Gomphus descriptus.—Study this older nymphal wing (Fig. 127, B). Identify the stems and the branches of the tracheae. Note the position of the radial sector. Compare this nymphal wing with Figure 127 A. It must not be forgotten that these lines are only tracheae. The veins have not been formed.

Fig. 128.—Nymphal metawing of *Gomphus descriptus*.

Gomphus descriptus.—Study the metawing (Fig. 128) of a full grown nymph. Identify the stems and the branches of the tracheae. Locate the bridge, the nodus, the subnodus, the arculus, and the anal tracheae and its method of branching. The fine tracheae about which the cross-veins are formed have not appeared.

Gomphus descriptus.—Study a mesowing and a metawing (Fig. 129) of a full grown nymph. Identify all the tracheae. The tracheoles about which the secondary veins are formed are present.

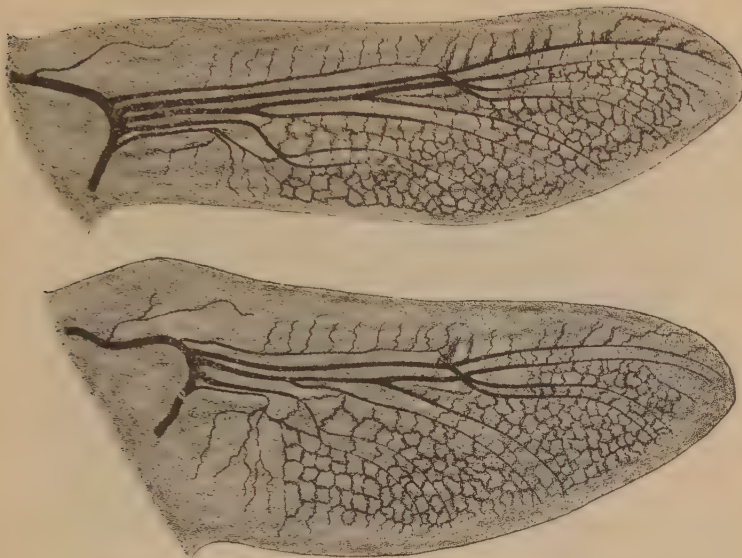

Fig. 129.—Wings of full grown nymph of *Gomphus descriptus.*

They have begun to assume a position similar to that of the veins of adult wings.

Libellula pulchella.—Study the nodal region (Fig. 130, A) of a nymphal wing. Label the tracheae at each end of the wing. Identify the bridge. Note how it originates. The number of fine tracheal branches in this type of bridge is considerable.

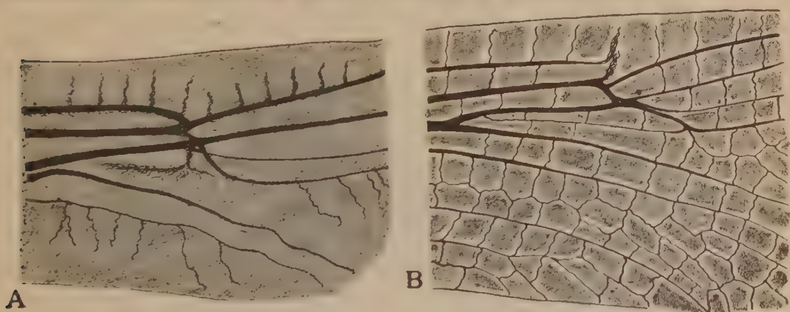

Fig. 130.—Wings of nymphs. Region of nodus. A, *Libellula pulchella*; B, *Lanthus parvulus.*

Lanthus parvulus.—Study the nodal region (Fig. 130, B) of a nymphal wing. The position of the veins are also shown. Label the tracheae at each end of the wing. Identify the bridge, compare it with that of Libellula.

Gomphus descriptus.—Note the course of the tracheae in the proximal third (Fig. 131) of the wing. Identify the stems of the tracheae. Some of the tracheoles about which secondary veins are formed, are present.

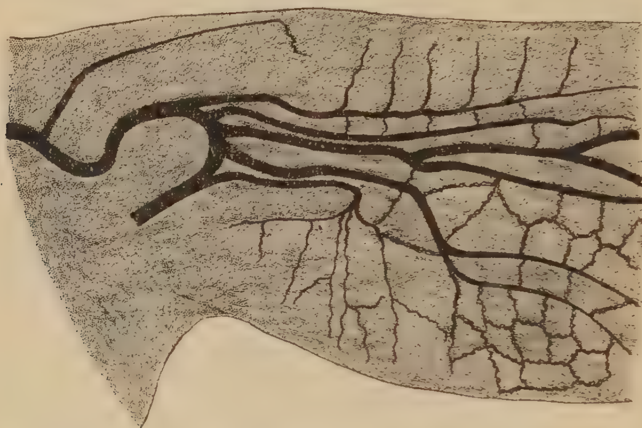

Fig 131.—Wings of nymph. Region of triangle. *Gomphus descriptus.*

Lanthus parvulus.—The position of the veins and tracheae (Fig. 132) are both shown. Label all the tracheae. Note the position of the stem of the anal trachea in the cubital vein and the course of the branches of the anal trachea. Identify the super-triangle and the triangle.

Agriogomphus sp.—These (Fig. 133) are considered as generalized wings. The number of secondary veins is not large.

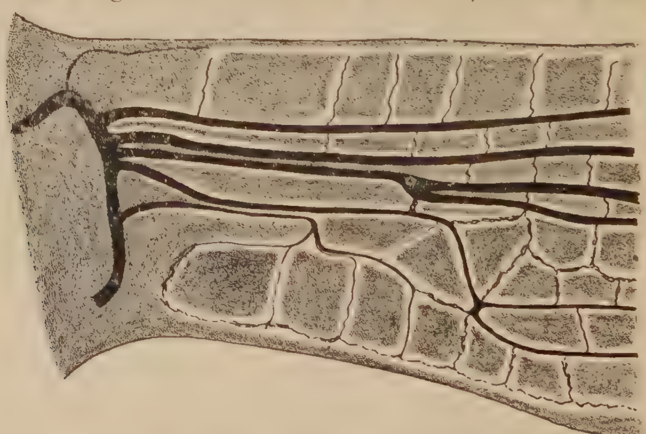

Fig. 132.—Wing of nymph. Region of triangle. *Lanthus parvulus.*

Compare them with the adult nymphal wings of Gomphus. Identify and label the stems and branches of the veins, the nodus, the subnodus, the stigma, the bridge, the arculus, and the triangle.

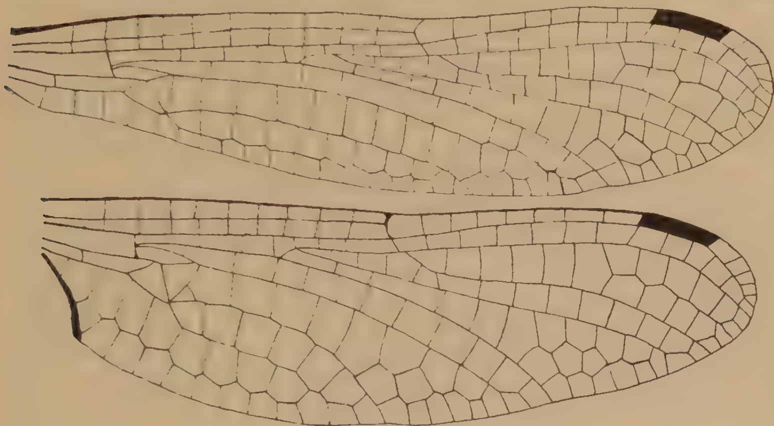

Fig. 133.—Wings of *Agriogomphus* sp.

Cordulegaster sayi.—These wings (Fig. 134) contain more secondary veins than Agriogomphus. Identify all the parts. Compare them with the adult nymphal wings of Gomphus and the wings of Agriogomphus. The stigma lacks oblique bracing veins. The oblique part of the radial sector is distinct. The bridge is

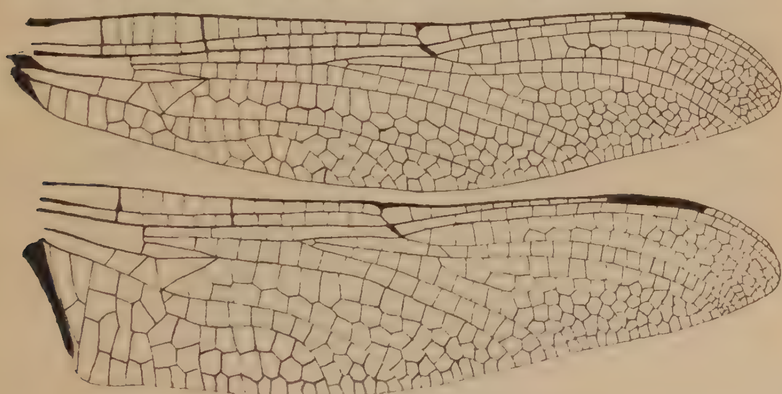

Fig. 134.—Wings of *Cordulegaster sayi.*

long. Media-four is distinctly separated from media-three. The subcostal trusses are thicker than the other cross-veins. Identify all the parts.

Gomphaeschna furcillata.—Compare these wings (Fig. 135) with Cordulegaster. Note the region of the arculus. Identify the small anal loop.

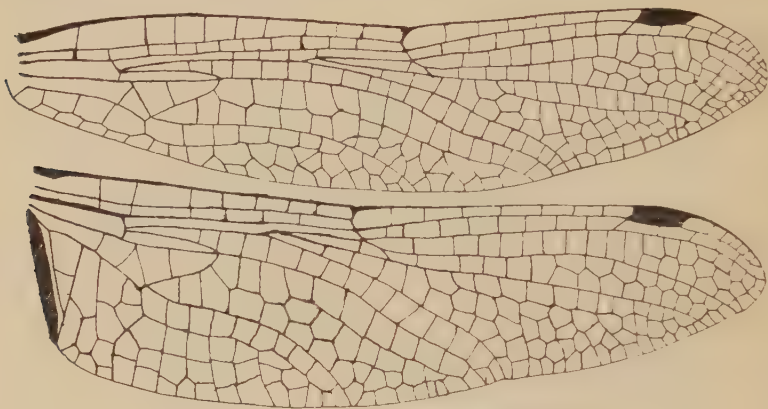

Fig. 135.—Wings of *Gomphaeschna furcillata.*

Lanthus parvulus.—Identify (Fig. 136) the veins. Compare with Gomphaeschna. Note the modifications of the anal region. It is supported by transverse veins instead of by an anal loop.

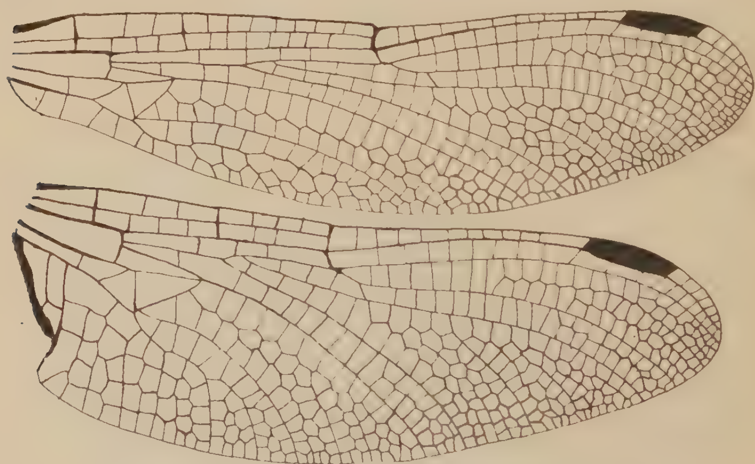

Fig. 136.—Wings of *Lanthus parvulus.*

Didymops transversa.—Identify (Fig. 137) the veins. Note the condition of the vein arising from the arculus. Compare it with that of Cordulegaster and Lanthus. Identify the anal loop, it is not well developed.

Oxygaster curtisii.—Examine (Fig. 138) the region of the arculus. Compare with Didymops. The anal loop is peculiar in form. The bridge is short and the oblique part of the radial sec-

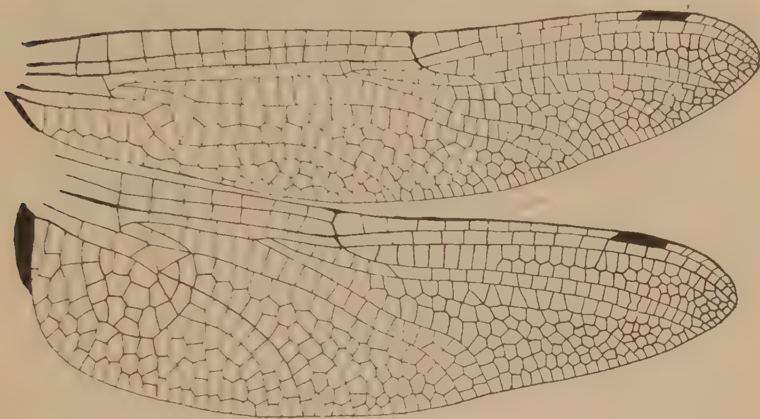

Fig. 137.—Wings of *Didymops transversus.*

tor is distinct. Media-four should be compared with Didymops and Pachydiplax. The subnodus and associated veins are distinctly thickened.

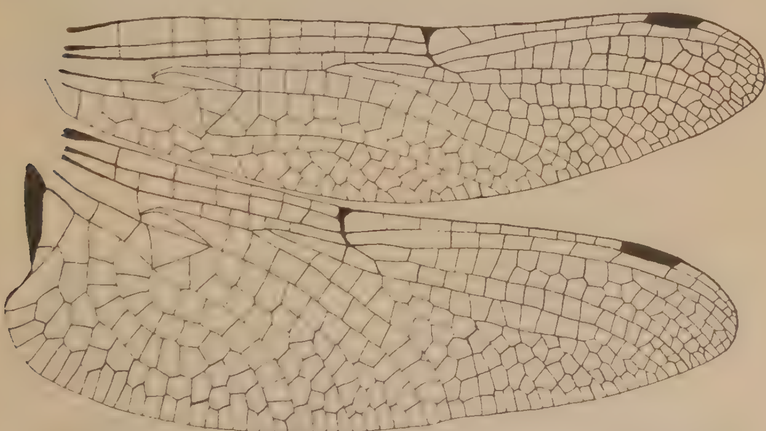

Fig. 138.—Wings of *Oxygaster curtisii.*

Pachydiplax longipennis.—Note the great number (Fig. 139) of secondary veins. The anal loop is large and distinctive. Label the veins. Oxygaster and Pachydiplax show a great enlargement of the anal region of metawing, which is characteristic of some genera.

Lestes rectangularis.—Identify (Fig. 140) the primary veins and tracheae. Note especially the bridge, the arculus, and the

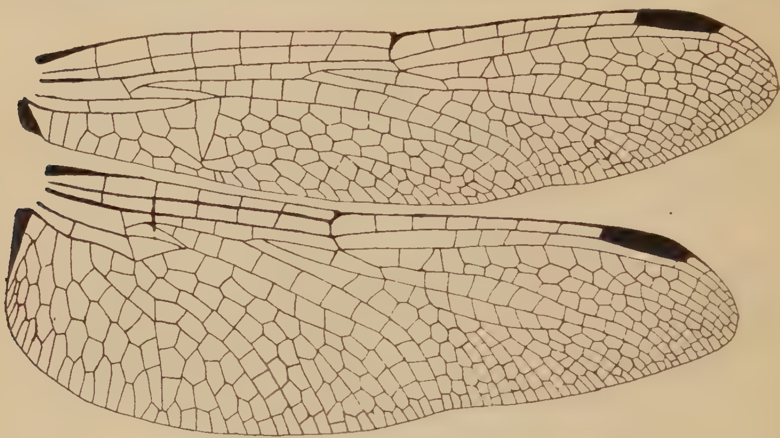

Fig. 139.—Wings of *Pachydiplax longipennis.*

radial sector. The tracheae of the cross-veins are distinct.

Archalestes grandis.—Compare (Fig. 141) with rectangularis.

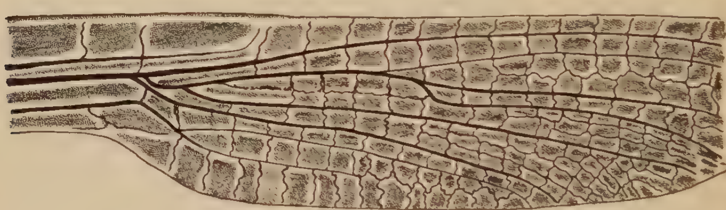

Fig. 140.—Nymphal wing of *Lestes rectangularis.*

This is one of the few wings of this group which has retained the free part of the radial sector as an oblique vein in the front wing.

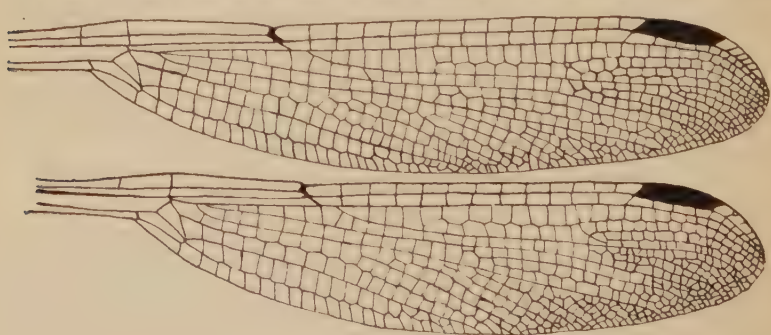

Fig. 141.—Wings of *Archalestes grandis.*

Lestes congener.—Compare (Fig. 142) these wings with rectangularis. Identify veins, their stems, bridge, nodus, and stigma.

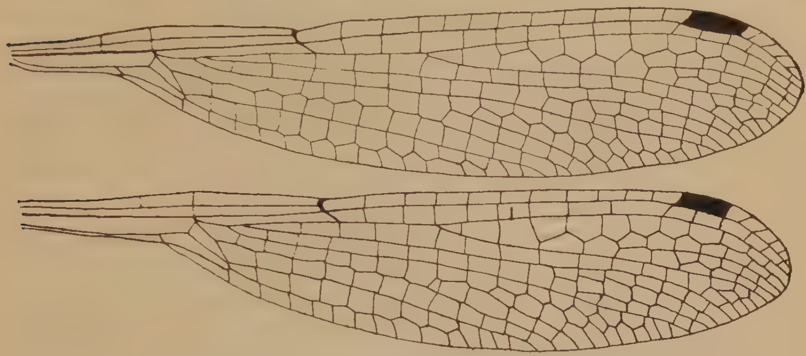

Fig. 142.—Wings of *Lestes congener*.

LIST OF SPECIES DESCRIBED

A complete list of all the species studied, their vernacular name where such exists, and their systematic position, family and order, is desirable, so that the student may know something more about the various species than simply their scientific name. This information is included in the following list. The length of the list is greatly extended through the large number of species used for the study of the wings and a few other parts.

ORTHOPTERA

Blatta orientalis.—Oriental Cockroach.—Blattidae.
Stagmomantis carolina.—Carolina Mantid.—Mantidae.
Gryllus pennsylvanicus.—Pennsylvania Cricket.—Gryllidae.
Gryllotalpa borealis.—European mole-cricket.—Gryllidae.
Melanoplus differentialis.—Grasshopper.—Acrididae.

ODONATA

Gomphaeschna furcillata.—Aeschnid.—Aeschnidae.
Cordulegaster sayi.—Cordulegasterid.—Aeschnidae.
Lanthus parvullus.—Gomphid.—Aeschnidae.
Gomphus descriptus.—Gomphid.—Aeschnidae.
Agriogomphus sp.—Gomphid.—Aeschnidae.
Libellula pulchella.—Libellulid.—Libellulidae.
Didymops transversus.—Macromiid.—Libellulidae.
Pachydiplax longipennis.—Libellulid.—Libellulidae.
Oxygaster curtisii.—Libellulid.—Libellulidae.
Lestes rectangularis.—Lestid.—Agrionidae.
Archalestes grandis.—Lestid.—Agrionidae.
Lestes congener.—Lestid.—Agrionidae.

HEMIPTERA

Tibicina septendecim.—Seventeen-year Locust.—Cicadidae.
Epoasca coccinea.—Red Leaf-hopper.—Jassidae.
Corsia kennicotti.—Water-boatman.—Corisidae.
Notonecta undulata.—Back-swimmer.—Notonectidae.
Benacus griseus.—Giant Water-bug.—Belostomatidae.
Reduvius personatus.—Masked Bed-bug Hunter.—Reduviidae.
Phymata wolffi.—Ambush-bug.—Phymatidae.
Euschistus variolarius.—Stink-bug.—Pentatomidae.

COLEOPTERA

Harpalus caliginosus.—Murky Hunter.—Carabidae.

Calosoma calidum.—Fiery Hunter.—Carabidae.
Triplectrus rusticus.—Rusty Hunter.—Carabidae.
Scarites subterraneus.—Lucanid-like Hunter.—Carabidae.
Geopinus incrassatus.—Thickened Hunter.—Carabidae.
Dineutes americanus.—Whirligig-beetle.—Gyrinidae.
Hydrous triangularis.—Water-scavenger.—Hydrophilidae.
Necrophorus americanus.—Burying-beetle.—Silphidae.
Silpha surinamensis.—Carrion-beetle.—Silphidae.
Staphylinus maculosus.—Rove-beetle.—Staphylinidae.
Tenebroides mauritannica.—Cadelle.—Trogositidae.
Parallelostethus attenuatus.—Click-beetle.—Elateridae.
Lucanus dama.—Common Stag-beetle.—Lucanidae.
Passalus cornutus.—Antelope Beetle.—Lucanidae.
Lachnosterna hirticula.—May-beetle.—Scarabaeidae.
Pinotus carolina.—Carolina Tumble-bug.—Scarabaeidae.
Prionus laticollis.—Broad-necked Prionus.—Cerambycidae.
Monochamus titillator.—A Sawyer.—Cerambycidae.
Tetraopes tetrophthalmus.—Milkweed-beetle.—Cerambycidae.
Leptinotarsa decemlineata.—Potato-beetle.—Chrysomelidae.
Blepharida rhois.—Halticid Leaf-beetle.—Chrysomelidae.
Dendroides bicolor.—Pyrochroid.—Pyrochroidae.
Meloe angusticollis.—Buttercup Oil-beetle.—Meloidae.
Sphenophorus aequalis.—Bill-bug Beetle.—Calandridae.

NEUROPTERA

Corydalus cornutus.—Dobson.—Sialididae.

HYMENOPTERA

Pleuroneura avingrata.—Xyelid.—Xyelidae.
Xyela modesta.—Xyelid.—Xyelidae.
Itycorsia luteomaculata.—Pamphiliid.—Pamphiliidae.
Pamphilius pallimacula.—Pamphiliid.—Pamphiliidae.
Strongylogastroidea apicalis.—Emphytid.—Tenthredinidae.
Strongylogaster annulosus.—Tenthredinid.—Tenthredinidae.
Periclista melanocephala.—Blennocampid.—Tenthredinidae.
Hemichroa americana.—Hoplocampid.—Tenthredinidae.
Pteronidea ribesii.—Currant Saw-fly.—Tenthredinidae.
Hylotoma virescens.—Hylotomid.—Tenthredinidae.
Metallus bethunei.—Blackberry Leaf-miner.—Tenthredinidae.
Schizocerus zabriskiei.—Purslane Saw-fly.—Tenthredinidae.
Loboceras frater.—Lobocerid.—Tenthredinidae.
Megalodontes spissicornis.—Megalodontid.—Megalodontidae.
Paururus cyaneus.—Horn-tail.—Siricidae.
Janus integer.—Currant Borer.—Cephidae.

Janus abbreviatus.—Willow Borer.—Cephidae.
Cryptus americanus.—Ichneumon-fly.—Ichneumonidae.
Aleiodes terminalis.—Braconid.—Braconidae.
Chaenon anceps.—Braconid.—Braconidae.
Aspilota ruficornis.—Braconid.—Braconidae.
Pammegischia ashmeadi.—Ensign-fly.—Evaniidae.
Gasteruption incertus.—Ensign-fly.—Evaniidae.
Leucospis affinis.—Chalcis-fly.—Chalcididae.
Perilampus hyalinus.—Chalcis-fly.—Chalcididae.
Camponotus herculeanus.—Carpenter Ant.—Formicidae.
Myzine obscura.—Scoliid.—Scoliidae.
Sceliphron caementarius.—Thread-waisted Wasp.—Sphecidae.
Notogonia argentata.—Larrid.—Larridae.
Bembex fasciata.—Bembecid.—Bembecidae.
Crabro chrysargyrus.—Crabronid.—Crabronidae.
Vespa maculata.—White-faced Hornet.—Vespidae.
Bremus vagans.—Bumble-bee.—Bremidae.
Apis mellifera.—Honey-bee.—Apidae.

LEPIDOPTERA

Sthenopis thule.—Swift Moth.—Hepialidae.
Micropteryx aureatella.—Little Jugate.—Micropterygidae.
Mnemonica auricyanea.—Chesnut Jugate.—Micropterygidae.
Prionoxystus robiniae.—Locust-tree Carpenter-moth.—Cossidae.
Parasa indeterminata.—Slug-caterpillar Moth.—Eucleidae.
Cydia pomonella.—Codlin-moth.—Tortricidae.
Lampronia quadripunctella.—European Lampronia.—Tineina.
Incurvaria praelatella.—European Incurvaria.—Tineina.
Nemotois metalicus.—European Nemotois.—Tineina.
Enicostoma lobella.—European Enicostoma.—Tineina.
Gelechia subocellea.—European Gelechia.—Tineina.
Metzneria carlinella.—European Metzneria.—Tineina.
Elachista reuthiana.—European Elachista.—Tineina.
Lyonetia clerkella.—European Lyonetia.—Tineina.
Cerura albicoma.—White Prominent.—Notodontidae.
Heterocampa lunata.—Lunate Prominent.—Notodontidae.
Eudule mendica.—The Beggar.—Geometridae.
Feltia subgothica.—Owlet-moth.—Noctuidae.
Feltia jaculifera.—Owlet-moth.—Noctuidae.
Agrotis ypsilon.—Owlet-moth.—Noctuidae.
Psychomorpha epimenis.—Owlet-moth.—Noctuidae.
Hemerocampa leucostigma.—Tussock-moth.—Lymantriidae.
Gnophaelia vermiculata.—Pericopid.—Pericopidae.
Halisidota caryae.—Hickry Tiger-moth.—Arctiidae.

Pygoctenucha funerea.—Tiger-moth.—Arctiidae.
Dahana atripennis.—Syntomid.—Syntomidae.
Cosmosoma auge.—Syntomid.—Syntomidae.
Ctenucha virginica.—Syntomid.—Syntomidae.
Lycomorpha pholus.—Syntomid.—Syntomidae.
Protoparce sexta.—Tomato-worm Moth.—Sphingidae.
Amisota rubicunda.—Rosy Dryocampa.—Citheroniidae.
Callosamia promethia.—Promethia-moth.—Saturniidae.
Malacosoma americana.—Tent-caterpillar.—Lasiocampidae.
Epargyreus tityrus.—Silver-spotted Skipper.—Hesperidae.
Papilio polyxenes.—Black Swallow-tail.—Papilionidae.
Pieris rapae.—Cabbage-butterfly.—Pieridae.
Danaus archippus.—Monarch.—Nymphalidae.

DIPTERA

Tanyderus australiensis.—Tanyderid.—Tanyderidae.
Tanyderus forcipatus.—Tanyderid.—Tanyderidae.
Protoplasa fitchii.—Tanyderid.—Tanyderidae.
Tricyphona protea.—Crane-fly.—Tipulidae.
Tricyphona calcar.—Crane-fly.—Tipulidae.
Neolimnophila ultima.—Crane-fly.—Tipulidae.
Cladura flavoferruginea.—Crane-fly.—Tipulidae.
Elephantomyia westwoodi.—Crane-fly.—Tipulidae.
Ptychoptera rufocincta.—Crane-fly.—Tipulidae.
Bittacomorpha clavipes.—Crane-fly.—Tipulidae.
Pachyrina ferruginea.—Crane-fly.—Tipulidae.
Tipula cunctans.—Crane-fly.—Tipulidae.
Brachypemna dispellans.—Crane-fly.—Tipulidae.
Megistocera longipennis.—Crane-fly.—Tipulidae.
Dixa fusca.—Dixa-midge.—Dixidae.
Culex pipiens.—Mosquito.—Culicidae.
Anopheles maculipennis.—Malarial Mosquito.—Culicidae.
Hesperinus brevifrons.—Fungus-gnat.—Mycetophilidae.
Mycomyia sequax.—Fungus-gnat.—Mycetophilidae.
Docosia nigella.—Fungus-gnat.—Mycetophilidae.
Rhyphus alternatus.—False Crane-fly.—Rhyphidae.
Tabanus sulcifrons.—Horse-fly.—Tabanidae.
Stratiomyia apicula.—Soldier-fly.—Stratiomyidae.
Leptis vertebratus.—Snipe-fly.—Leptidae.
Eulonchus tristis.—Small-headed Fly.—Acroceridae.
Rhynchocephalus sackeni.—Tangle-veined Fly.—Nemistrinidae.
Promachus vertebratus.—Robber-fly.—Asilidae.
Erax bastardi.—Robber-fly.—Asilidae.
Midas clavatus.—Midas-fly.—Midaidae.

Rhaphiomydas acton.—Apiocerid.—Apioceridae.
Pantarbes capito.—Bee-fly.—Bombyliidae.
Scenopinus fenestralis.—Window-fly.—Scenopinidae.
Hilara trivittata.—Dance-fly.—Empididae.
Hybos triplex.—Dance-fly.—Empididae.
Psilopus sipho.—Long-legged Fly.—Dolichopodidae.
Pelastoneura vagans.—Long-legged Fly.—Dolichopodidae.
Eristalis tenax.—Syrphus-fly.—Syrphidae.
Conops affinis.—Thick-headed Fly.—Conopidae.
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Musca domestica.—House-fly.—Muscidae.

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